# JOURNAL OF DAIRY SCIENCE

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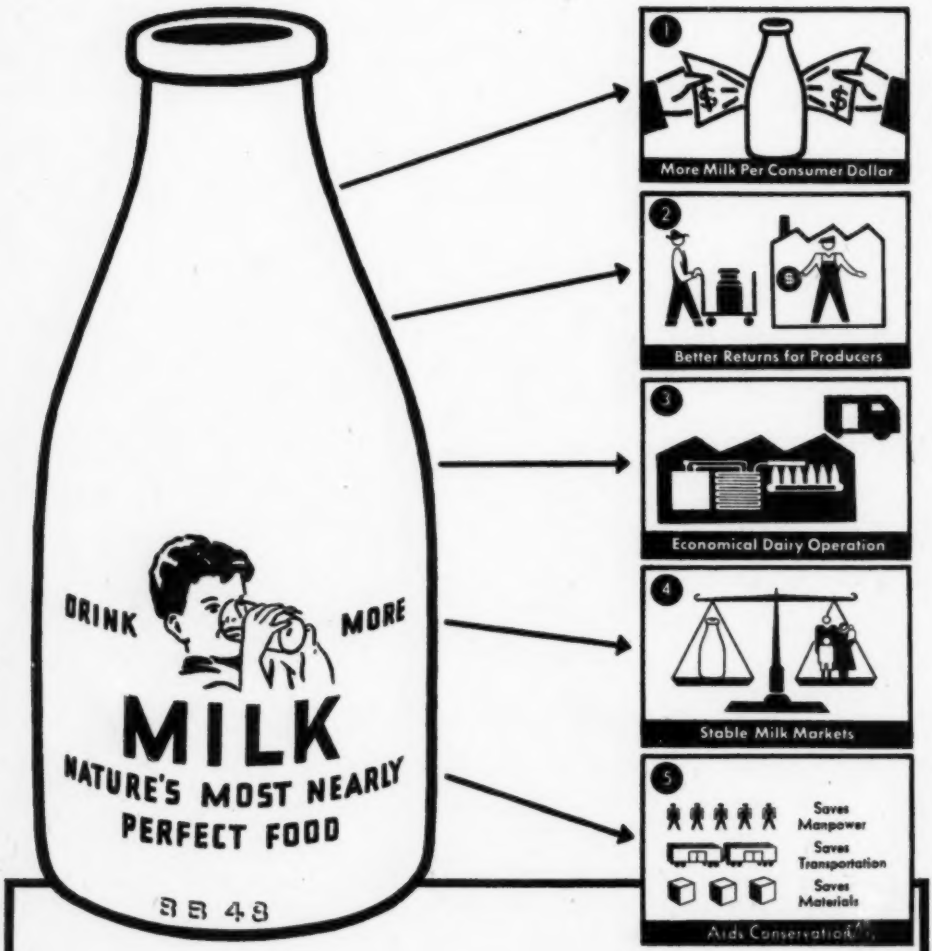


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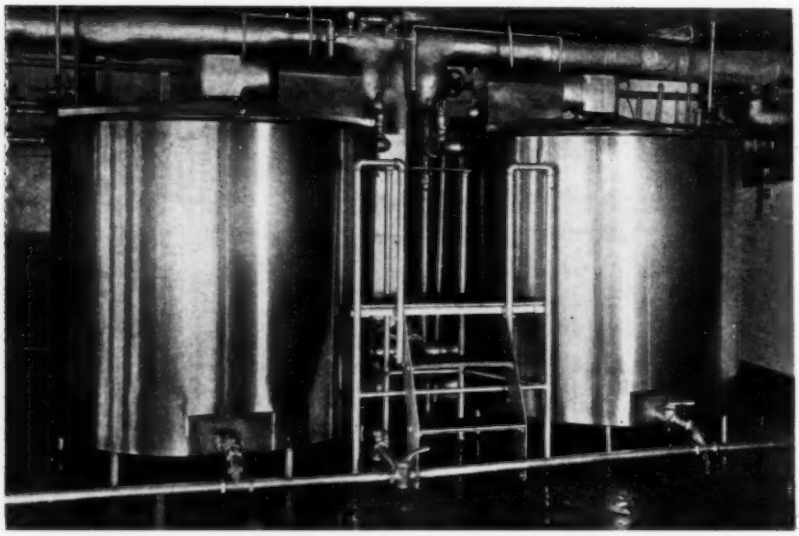

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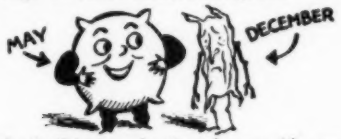


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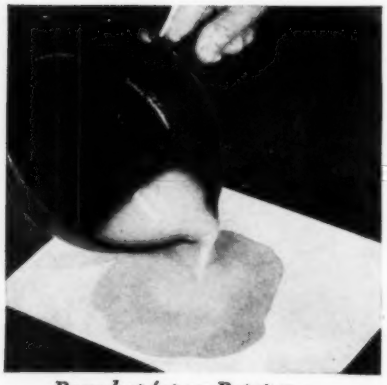

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VOLUME XXVII OCTOBER, 1944 NUMBER 10

# THE EFFECT OF THE METHOD OF MANUFACTURE OF BUTTEROIL ON ITS KEEPING QUALITY*

M. S. EL-RAFEY,[1] G. A. RICHARDSON, AND J. L. HENDERSON
*University of California, Davis*

For centuries butteroil has been prepared and used in Egypt, India, and other countries in the Middle East, where it is called Samn, Ghee, and Maslee respectively. The preparation is usually made in small units, and the process is called "boiling-off." Its origin is not well known, since it is a development of traditional farmhouse practice. The method consists mainly of heating the butter in an open kettle with continuous stirring until all the water is boiled off. The non-fat solids precipitate to form a brown sediment, which can be strained from the butteroil. This sediment (called Mourta in Egypt, Chhas in India, and Ankenrume or Lure in Switzerland and Germany) is used as a spread, in cooking, or is fed to animals. Although the boiling-off method is being used in Switzerland, Sweden, France, and other European countries, there is no definite standard procedure with respect to temperature control. Butteroil, when correctly prepared by this method, acquires a special pleasant aroma.

Parnerker (24) has recently recommended to Indian farmers a modified method designed for saving both fuel and fat. In this process the butter is melted and allowed to stand in a cool place to solidify the fat; then the butter serum is drained off, and the fat is boiled in the usual manner.

The modern ways of preparing butteroil on a commercial scale may well be called the centrifugal methods. These are used in New Zealand, Australia, and Germany, and have recently been recommended in the United States (12). In all these methods the butter serum is partly removed by the centrifuge; but the details differ in each country. The butteroil thus prepared has a pleasant, delicate flavor, but lacks the aroma of that obtained by boiling-off process.

New Zealand has developed a continuous process by which low-moisture, unsalted butter and unsalted whey butter are converted into butteroil (28). The butter is melted by direct steam; the oil is floated off; the oil in the serum

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[1] On leave from Fouad First University, Cairo, Egypt.



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is recovered by centrifuging and is combined with the main bulk of the oil. The oil is then passed in turn through the separator, heater, separator, dehydrator, and rotary cooler, and finally into specially constructed containers.

In the Australian method (1) the butter serum is adjusted to pH 10 by the addition of caustic soda. This alkalization is claimed to be beneficial in increasing the rate of separation and the speed of dehydration. The mixed melted butter is stirred, passed through two whey separators, without gravity separation or additional heating, and fed directly into a continuous vacreator. It is cooled in an internal tubular cooler and packed. The Australian and New Zealand butteroil thus prepared is called dry butterfat.

In the German method suggested by Mohr (20) in 1940, the butter is melted, clarified, and centrifuged at 70° C.; then the fat is heated at 105–115° C., cooled, and packed.

The recent method of Holm (12, 13), which is suggested for use in the United States, does not appear to have been applied to large scale manufacturing. The object, apparently, is to produce butteroil in highly purified form; and the method depends upon removal of oxygen and packaging of the product in an inert gas for preservation against oxidative deterioration. The butter is melted, the serum is separated by gravity, and the fat is passed through a cream separator to remove the excess water and curd. If the fat is not entirely clear, it is washed with warm water and reseparated. It is then vacuum dried with agitation to remove the final traces of water and gases. The oil is vacuum packed and sealed under an atmosphere of nitrogen (14).

The conventional procedure for preparing butteroil in the research laboratory may be called the filtration method. Butter melted at about 50° C. is left to separate into three layers. The serum layer at the bottom is drawn off, the yellowish white layer at the top is skimmed away, and the middle butteroil layer is filtered. The crystal-clear product thus prepared is used for studies related to milk fat.

Butteroil of commercial purity should contain not more than 0.1 per cent of either water or non-fat solids. The water content is of special significance, since it may vary between 0.08 and 0.3 per cent. As shown earlier, (31, V) a water content above 0.15 per cent may cause rusting of the metal containers unless the butteroil is forced to form fine crystals by rapid cooling or inoculation. If the moisture is 3 per cent or over, the oil may become susceptible to spoilage by microorganisms, a condition that rarely exists where proper control is maintained.

The main type of deterioration which develops in butteroil on prolonged storage is that of oxidative rancidity, and one may naturally suspect that resistance to oxidation may vary with the method of preparation. The war emergency has emphasized this problem, since the shipping of butteroil to the armed forces and to the allied and dependent nations in place of butter

would save 20 per cent tonnage and eliminate or greatly reduce the need of refrigeration in transportation and storage. Another problem concerns the effect of the manufacturing method on the preservation of the vitamin A and carotene content, both in processing and in storage.

Patil and Hammer (25) compared the stability of filtered butteroil not heated above 55° C. with that of ghee prepared by boiling-off and brought to 140° C. They concluded that a high temperature of heating is not necessary, since the keeping quality of the two during 23 weeks of storage at room temperature was about the same. Ritter (29), on the other hand, after a similar comparison, concluded that butteroil prepared by the boiling-off method is more resistant to the development of oxidized flavor than filtered fat. Mohr (19), comparing butteroils filtered at 50° and 90° C. and ghee prepared at 110° C. found that after 7 months the ghee was superior, but that the difference had disappeared by the end of 11 months. According to Ritter and Nussbaumer (30), butteroil is less susceptible to oxidation when filtered at 100° rather than 42° C. Later Ewbank and Gould (6) concluded that heating butter or butteroil to 127° C. for 30 minutes hastens the oxidation. The heated butter was filtered at 80° to 90° C., but, as they pointed out, when a similar sample is filtered at 45° C. the resulting butteroil is more stable than heated butteroil.

The effect of processing on the vitamin A activity of butteroil has been studied somewhat. Grewal (9) reported that butteroil prepared by the centrifugal method is higher than that by the Indian method. According to Banerjee and Dastur (2), vitamin A in ghee is fairly stable up to 125° C. being rapidly destroyed at higher temperatures; and the vitamin in the oil prepared from cow's milk is more stable to heat than in that from buffalo's milk. They attributed the difference to the relative absence of carotene in the buffalo milk fat. Muthanad and Seshan (21) later found that ghee heated to 100° C. for 5 minutes lost some vitamin A.

## PREPARATION OF BUTTEROIL

Sweet cream was churned in glass, and the resulting butter was washed and used for preparing butteroil by the following methods:

1. The butter was melted at 70° C. in specially constructed glass equipment enclosed in a black-painted wooden case to minimize the effect of light. The equipment consists of a glass tube 3¼ inches in diameter and about 11 inches long, connected at the upper flanged end with a flanged, removable dome that has ground-glass connections to a vacuum line, a stirring motor, and a thermometer. The lower end of the tube is tapered and connected to a two-way vacuum stopcock. The tube is surrounded with a water jacket, through which water is circulated from a thermostatically controlled water bath. After the butter was melted, the butter serum was drawn from the bottom through one of the stopcocks, the other being left for drawing the

butteroil. The milk fat was then dried with continuous stirring at 70° C. under 26 inches of vacuum. The dry butteroil, which was partly cloudy, was clarified by centrifuging in bottles for 5 minutes at a low speed. The process took about 90 minutes and was planned to be comparable in the essential steps to some centrifuged methods.

2. The butter was treated exactly like the previous sample except that after it was melted and the butter serum was separated by gravity and drawn off, the fat was washed twice with distilled water at 70° C., then dried under vacuum and centrifuged in bottles. This type was prepared to show how the purifying of butteroil by washing affects its keeping quality.

3. Butteroil was prepared by heating the butter with continuous stirring in a glass beaker over a Bunsen burner to 105°–110° C. until all the water had been evaporated and the non-fat solids settled. The temperature was then raised to 130° C. As the temperature approached 120° C., the butteroil formed a relatively stable foam, which dissolved back in the fat on cooling. The fat was dark and had the characteristic aroma of the butteroil prepared by the boiling-off process with an additional heated flavor and odor. The fat was then clarified by centrifuging in the same way as the samples 1 and 2 (above), and the dark brown sediment removed. The process took about 75 minutes.

4. The butteroil was prepared by the boiling-off method, but its temperature was not permitted to rise above 110° C. It was then centrifuged in bottles. The resulting fat was clear, appeared slightly darker than the washed fat (sample 2), and had a special pleasant aroma, with no heated odor. The process took about 60 minutes.

5. The butter was melted in an oven at 70° C., the top layer was skimmed away and the serum drawn off, and the fat was filtered in the usual manner. The resulting fat was crystal clear. The process took about 150 minutes—the time obviously depending upon the volume of fat and the number of filters used.

6. Butteroil prepared by the filtration method (sample 5) was heated to 130° C. for 30 minutes. Significantly, this fat did not foam even up to a temperature of 145° C.

In each set of experiments, butter from the same lot was used for preparing samples described above. Then the butteroil, divided into small portions, was stored at 2° C.

## THE EFFECT OF THE METHOD OF PREPARATION ON THE RESISTANCE OF BUTTEROIL TO OXIDATION

The method used to determine the peroxide values of the butteroil is Wheeler's as modified by Henderson and Young (11). From each sample 4-ml. portions were heated in a thermostatically controlled oil bath at 79.5° C. shielded from direct sunlight. The values reported are millimoles

of peroxide per 1000 grams of fat. The results of different sets of experiments were quite uniform and are represented in figure 1.

As this figure shows, the method of preparation markedly affects the stability of the resulting butteroil. In this experiment the butter was prepared from raw cream of high quality. Evidently the boiling-off method gives the most stable fat; and the stability is slightly greater in sample 3, heated to 130° C. than in sample 4, heated to 110° C. Clearly, too, the filtered fat is less stable than samples 1 and 2, which were dried under vacuum and then clarified by centrifuging. Unlike the case of sample 3,

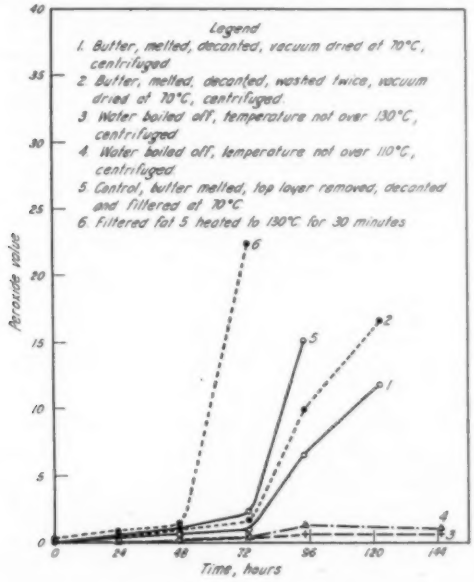


*Fig 1. The effect of the method of preparation on the resistance of butteroil to oxidation at 79.5°C. (Made from raw cream butter)*

heating the filtered fat to 130° C. (sample 6) impaired its stability. Sometimes, in comparing samples similar to 1 and 2, where the only difference in treatment is the washing given No. 2, the difference in stability was even greater than is shown in figure 1. As before, washing the butteroil decreased its resistance to oxidation. In one set of experiments, for example, the washed fat equivalent to sample 2 had passed the end of its induction period after 120 hours (which is taken arbitrarily as a peroxide value of 5), while the untreated sample 1 had reached a value of only 2.1.

## THE ACID VALUES OF BUTTEROIL

High acidity of butteroil was reported to have an undesirable effect on the stability of fat against oxidation and the destruction of vitamin A by

heat (3). The acid values of butteroils were determined by the Official Method and reported as per cent oleic in table 1. These values are approximately the same except for sample 3, where butteroil was prepared by the boiling-off method at 130° C. The difference, however, is not significant, since it was not evident when the experiments were repeated. In another trial when the butteroil was prepared from pasteurized cream butter, the acid value was found to be low, ranging between 0.12 and 0.16 per cent. Apparently, therefore, the method of preparation has no significant effect on the hydrolysis of the fat.

TABLE 1

*The effect of the method of preparation of butteroil on its acid values, phosphorus content and vitamin A activity (butteroil from raw-cream-butter)*

| Method of preparation | Acid value as oleic | Phosphorus as lecithin | Carotene | Vitamin A | Total reducing substances as tocopherol |
|---|---|---|---|---|---|
| | % | % | γ/gm. | γ/gm. | γ/gm. |
| 1. Butter melted, decanted, vacuum dried at 70° C., centrifuged | 0.365 | 0.151 | 3.39 | 4.89 | 146 |
| 2. Butter melted, decanted, washed twice, vacuum dried at 70° C., centrifuged | 0.326 | 0.0114 | 3.52 | 4.81 | 137 |
| 3. Water boiled off at 105–110° C., temperature increased to 130° C., centrifuged | 0.444 | 0.0805 | 3.23 | 4.32 | 364 |
| 4. Water boiled off, temperature not over 110° C., centrifuged | 0.385 | 0.0503 | 3.27 | 4.27 | 214 |
| 5. Control, butter melted, top layer removed, decanted and filtered at 70° C. | 0.365 | 0.0073 | 3.58 | 4.61 | 130 |
| 6. Number five fat heated to 130° C. for 30 minutes | 0.370 | ..... | 3.43 | 4.57 | 112 |

### THE EFFECT OF THE METHOD OF PREPARATION ON THE VITAMIN A AND CAROTENE CONTENT OF THE BUTTEROIL[2]

The Carr-Price antimony trichloride reaction was used for vitamin A determination, the readings being taken at the wave length of 620 mμ, using a Coleman Universal Spectrophotometer, Model 11. The carotene content was determined colorimetrically by extracting the color from the ether-soluble, unsaponifiable fraction of the butteroil, using Skellysolve B, extracting the xanthophyll with methanol, and reading at the wave length of 440 mμ. The values are expressed as micrograms of vitamin A and Beta carotene per gram of butteroil.

[2] The authors are indebted to Miss M. L. Long for these determinations.

Judging from table 1, the method of preparation has little or no effect upon the preservation of the vitamin A activity during processing. The differences are not considered significant inasmuch as they are not consistent from one set of samples to another.

### TOTAL REDUCING SUBSTANCES MEASURED AS TOCOPHEROL

The tocopherols, being known to act as antioxidants for fats (22), might account for the differences in the stability of the butteroil. Vitamin A and carotene are known to interfere with the determination; but, since all samples contained essentially the same concentration of vitamin A and carotene, analyses were made directly on the fat. Into a 10-ml. volumetric flask were weighed 4 grams of the butteroil; and the volume was made up with hexane. To 5 ml. of the fat solution was added 20 ml. of Emmerie and Engel reagent (5). The colorimetric readings were made with a Coleman spectrophotometer Model 11 at 525 mμ, after 45 minutes, using a solution that contains the reagents and 1.4 grams pure triolein as a reference. The readings were converted to tocopherol values from a calibration curve (made with α-tocopherol) and are reported in table 1 as the total reducing substances.

These results show, for the reducing substances of butteroils, a wide variation that cannot reasonably be attributed to variation in the tocopherol content. Significantly, however, these total reducing substances can be directly correlated with the stability of the fat against oxidation. They are highest in the butteroils prepared by the boiling-off method, lowest in the filtered fat that is heated to 130° C.

As further work has shown, the compounds that have the sulfhydryl group, such as glutathione, give a red color with the Emmerie-Engel reagent. Further experiments were planned, therefore, to determine how glutathione affects the oxidation of butteroil.

In this experiment filtered fat was used and divided into two portions. To the first lot 50 mg. of pure glutathione dissolved into 10 ml. of water was added to 100 ml. of fat; the water was then boiled off by heating in an oven at 100° C. and 20 inches vacuum. The other lot was used as a control; 10 ml. of distilled water per 100 ml. of fat was added to it, and the water boiled off in the same manner. The fat containing the glutathione reached the end of its induction period in 96 hours, as compared with 24 hours for the control.

We may reasonably assume, therefore, that sulfhydryl groups produced by the effect of heat on the protein part of the fat globule membrane (8), and probably other reducing substances are transferred to the butteroil in the process of its preparation by the boiling-off method and there act as antioxidants. This assumption may explain part of the high reducing substances in samples 3 and 4 and may be related to their high stability. No specific method for determining the sulfhydryl groups in butteroil was available; but these groups do evidence themselves by the heated odor and flavor in sample 3.

THE EFFECT OF α-TOCOPHEROL ON THE STABILITY OF BUTTEROIL

The previous experiment did not exclude the possibility that variation in the tocopherol content of the butteroil is a factor in the resistance to oxidation. Pure α-tocopherol was added, therefore, to the filtered fat; the effect on stability was observed. Figure 2 shows the amounts added and the results obtained.

Judging from the peroxide-accumulation curves, the activity of α-tocopherol as an antioxidant is not proportionate to its concentration. If a per-

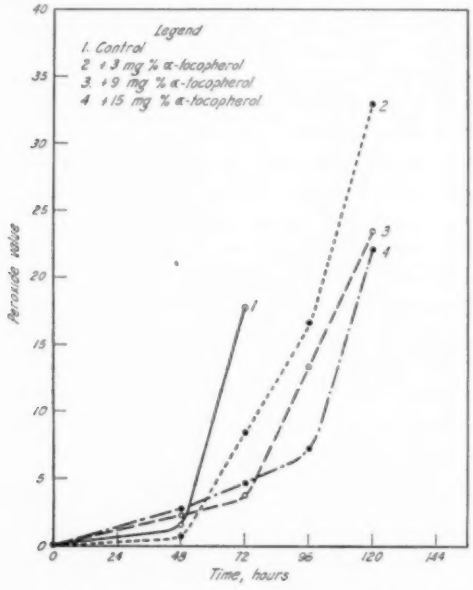


Fig. 2. The effect of adding α-tocopherol to butteroil on its resistance to oxidation at 79.5 °C.

oxide value of 5 is assumed to be the end of the induction period, then both samples that contain 9 mg. and 15 mg. per cent α-tocopherol would have about the same induction period. The accumulation of the peroxides during the induction period is less for the sample to which 3 mg. per cent α-tocopherol is added. These findings agree with the report of Swift, Rose, and Jamieson (32) on the effect of adding α-tocopherol to the methyl esters of cottonseed oil. The addition of as much as 15 mg. per cent α-tocopherol does not make the filtered fat nearly so stable as that prepared by the boiling-off method. Probably, then, the additional stability of samples 3 and 4 does not result from a more favorable transfer of tocopherol to the fat by the method of preparation.

### THE EFFECT OF THE METHOD OF PREPARATION ON THE PHOSPHORUS CONTENT OF THE BUTTEROIL

The phospholipids occur naturally in milk and are highly concentrated around its fat globules as phospholipid-protein complexes. These compounds are known to act as antioxidants in fats, and several individual fractions have been patented. The literature on this subject has been reviewed recently by Mitchell and Black (18). It is also common knowledge that the phospholipids are surface active and tend to orient themselves at the interfaces. If, therefore, the water phase is completely removed by boiling, where do the phospholipids go? To test this point the butteroils were ashed according to Halliday (10), and the phosphorus was determined by the colorimetric method of Fiske and Subbarow (7). The results were converted to per cent lecithin by assuming that the phosphorus in the sample was combined in a stearyloleyl lecithin containing 3.85 per cent phosphorus.

As table 1 indicates, in preparing the butteroil by the boiling-off method (sample 3) the phosphorus content of the fat calculated as per cent lecithin increases from 0.0073 in the filtered fat to 0.0805 in the heated fat. The phosphorus content of the butteroils is directly correlated with its stability against oxidation. Apparently, therefore, the most satisfactory method of preparation is the one that ensures the transfer of a high phospholipid value to the fat. Part of this phosphorus might originate in a protein fraction held as a suspensoid in the fat. Additional experiments were planned to ascertain how the addition of phospholipid to the filtered butteroil will affect the stability against oxidation.

### THE EFFECT OF ADDING PHOSPHOLIPID ON THE STABILITY OF BUTTEROIL

Commercial soybean phospholipid was used as a source, from which the partly purified phospholipid was obtained by repeated extraction with ether and precipitation from acetone. The cream-white phospholipid thus secured was added to the filtered fat in concentrations that approximate those found in the different butteroils prepared. Figure 3 reports the results.

The peroxide-accumulation curve shows the striking effect of increasing concentrations of phospholipid on the stability of the butteroil. The sample that had 0.1 per cent phospholipid approached but did not quite equal the stability of the butteroils prepared by the boiling-off methods. Conceivably, the phospholipid in this concentration might increase the stability of the fat if it acted synergistically with $\alpha$-tocopherol.

### THE SYNERGISM BETWEEN PHOSPHOLIPID AND $\alpha$-TOCOPHEROL IN BUTTEROIL

One of the phospholipids, cephalin, has been shown by Olcott and Mattill (23) to co-act with the tocopherols in a most remarkable manner, in stabilizing the purified fatty acids esters and lard against oxidation. To test this

co-action or synergism in butteroil, α-tocopherol and purified soybean phospholipid were added to filtered fat in three different combinations. For the sake of comparison the same fat was used in samples reported in figures 2, 3, and 4.

The peroxide curves in figure 4 show some interesting facts. There is some synergetic action on adding small amounts of phospholipid and α-tocopherol. (Compare No. 2 fat—figures 2, 3, and 4.) On the other hand, when the amount of phospholipid added is 0.10 per cent with various amounts of tocopherol, the protective action seems to be due to the presence

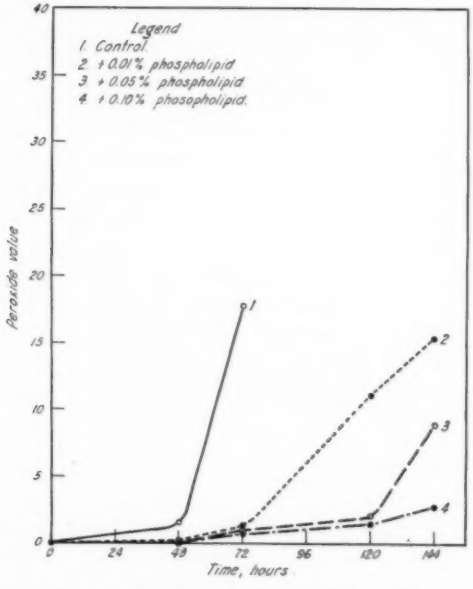


Fig. 3. The effect of adding purified soybean phospholipid to butteroil on its resistance to oxidation at 79.5°C.

of phospholipid, and the addition of 15 mg. per cent α-tocopherol seems to be less beneficial than adding 3 mg. per cent. (Compare fats 3 and 4 in figure 4 with No. 4 in figure 3.)

These results show, however, that the synergetic action of the phospholipid and α-tocopherol does not account completely for the stability of the butteroil prepared by boiling.

## DISCUSSION

Most important of the deteriorative changes that may occur in fats and oils on storage is oxidative rancidity; and butteroil is no exception. A recent review on the subject (18) summarizes the logical means of preventing these reactions as being either protection from oxygen, as exemplified

by vacuum packing, or the use of antioxidants. Evidence is here presented to show that the method of preparing butteroil from butter has a marked influence on its resistance to oxidation. Assuming that the end of the induction period is reached when the peroxide value is 5, the data indicate that butteroil is least stable when prepared by filtration. Washing of the fat is also detrimental to its stability. On the other hand, butteroil prepared by boiling off is shown to be considerably more stable; but it acquires a distinct heated odor and flavor if the temperature of the fat rises above

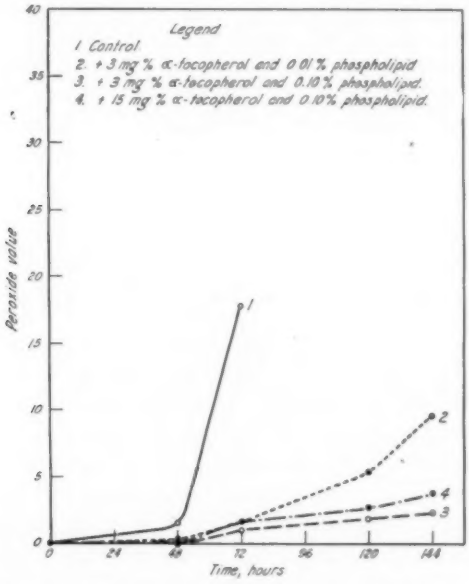


Fig 4. The effect of adding α-tocopherol and purified soybean phospholipid to butteroil on its resistance to oxidation at 79.5°C.

110° C. The additional stability gained by heating to 130° C. in the boiling-off method is not believed to be great enough to offset the disadvantage of a cooked flavor.

The stability of butteroil is found to be associated with an increase in the phosphorus content and the total reducing substances in the fat. The vitamin A, the carotene, and the acid values of the fat do not change appreciably with the manipulations used. The stability of butteroil made by the boiling-off method cannot well be attributed to a destruction of certain oxidative enzymes (20), because heating filtered fat to 130° C. reduces its stability. Likewise, the shortening of the induction period of the latter fat may not be due to the destruction of natural antioxidants, as others have suggested

(6, 30, I), but more likely is caused by pushing the fat further towards the end of its induction period during the heating. According to Ritter and Nussbaumer (31, VI), diacetyl acts as a prooxidant in butteroil; conceivably, therefore, when these are removed by steam distillation in the boiling-off process the stability of the fat increases. The results of experiments not reported herein show, however, that when 10 to 20 per cent water is added to the filtered butteroil and then removed by boiling, the stability of the fat is reduced.

The data reported support the assumption that when butteroil is prepared from butter by boiling off the water in the presence of the non-oil phase, the protein of the phospholipid-protein complexes in the non-oil residue is so denatured that the phospholipids are free to dissolve in the oil. An increase in the stability and foaming capacity of the oil results. This assumption, previously made (27, 29), is substantiated by the fact that good stability is associated with a high phosphorus content. It is also strengthened by the data (fig. 4) showing that the addition of purified soybean phospholipid increases the stability of filtered butteroil. The significance of the freeing of an organic compound from its protein posthetic group by means of heat is being increasingly recognized in relation to vitamin preservation during dehydration or storage of foods (4, 26).

Judging from comparison of sample 4 in figure 2 with sample 3 in figure 4, however, the phospholipid content is not the only factor that accounts for the differences in their stability, since both fats contain about 0.05 per cent phospholipid. The higher content of the total reducing substances in the former sample probably also contributes to its stability. These compounds reduce ferric chloride to ferrous, as is shown by their reaction with the Emmerie-Engel reagent. They cannot, however, all be considered as tocopherol, since the sulfhydryl group present in glutathione interferes with the test; this group also prolongs the induction period of the butteroil. These groups are known to be released from the proteins surrounding the fat globules in milk by the effect of heat; they act as antioxidants (8, 15). The liberation of the heat-volatile sulfides of milk is of great current interest (33). Though there seems to be no chemical test to determine these groups in fats, they evidence themselves by the cooked flavor they impart to fats heated to 130° C. in the presence of butter serum. Other reducing groups produced by the heating of the proteins belong to tyrosine and tryptophane (17). Marvel (16) patented the use of tyrosine and its esters as antioxidants in edible fats and oils. Attempts to determine these specific groups in butteroil prepared by the boiling-off method are in progress.

The addition of $\alpha$-tocopherol to the filtered fat does not prolong the induction period of the latter to the same extent as in the boiled-down fat. In the presence of 0.1 per cent phospholipid, the addition of 3 mg. per cent of $\alpha$-tocopherol seems to be more beneficial than larger amounts, and some

synergism is observed. Unless the tocopherols in milk are shown to be largely associated with the proteins in a complex form, one cannot well conceive that a wide variation occurs in the tocopherol content of butteroils prepared by different methods. The values reported in table 1 are calculated as tocopherols for convenience only. They indicate, however, the concentration of all the substances present in the butteroil that reduce ferric chloride in 45 minutes. All these seem to act synergistically with the phospholipids in protecting the boiled-down butteroil against oxidative rancidity.

No method of manufacture tested appreciably affects the vitamin A and the carotene content of the fat. The higher concentration of compounds of known biological value—namely, the phospholipids—in the oils prepared by certain methods may add to nutritional value, as well as to stability. Increased stability indicates increased protection against the destruction of vitamin A activity.

## SUMMARY

Butteroil* made by the process in which butter is heated to 110° C. to drive off the moisture, the residue being removed by centrifuging, has been found to be more resistant to oxidative rancidity than when lower temperatures of isolation of the oil are used. The improved keeping quality has been shown to result from the transfer of greater amounts of phospholipid material from the non-oil phase of butter to the oil, presumably because of the denaturing action of heat on the protein of the phospholipid-protein complex. The concentration of reducing substances is also higher in the butteroil made by the "boiling-off" process than by the low heat treatment.

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* The authors feel that 'dry milk fat' would be a more descriptive terminology, and essentially correct.

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# THE NUTRITIVE VALUE OF ALFALFA HAY. II. STARCH AND GLUCOSE AS SUPPLEMENTS TO AN ALL ALFALFA HAY RATION*

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It has been recognized for a long time that when a hay crop is fed alone it does not produce growth, meat or milk as efficiently, per pound of ingested total digestible nutrients, as when the ration is supplemented with concentrates. Several investigators have reported that a ration composed entirely of alfalfa hay appeared to be deficient in some factor or factors necessary for milk production (37, 33, 15, 14, 22, 17). Graves *et al.* (13), however, found that the average yearly production of a group of cows was 376 pounds of butterfat on a ration of alfalfa hay alone, which indicated efficient utilization of the total digestible nutrients. These investigators reported also that another group of cows produced 395 and 357 pounds of butterfat per year on alfalfa alone during their first and second lactation periods. Dawson and coworkers (5) found that a group of cows produced 392 pounds of butterfat on alfalfa cut at the initial-bloom stage, 326 pounds on alfalfa cut at the half-bloom stage, and 311 pounds when the alfalfa was cut at full-bloom. According to the results obtained by Willard (36) on an all hay ration, cows increased their milk production when they were changed from poor quality alfalfa to a better quality alfalfa hay. It appears from a review of the literature that occasionally certain alfalfa hays are more efficient than others for milk production when fed alone.

The factor or factors in grain which increase the nutritive value of alfalfa hay may be available energy. Crampton (4) fed one group of rabbits mixed pasture grasses alone, a second group received mixed pasture grasses plus 5 per cent casein and a third group received mixed pasture grasses plus 5 per cent sucrose. The group on grass alone lost 134 grams in weight whereas the groups that received the casein and sucrose supplements each gained 30 grams in weight. It was concluded that the failure of mixed grasses to produce gains in weight was due to a lack of available energy. Kellner and Köhler (24) studied the effect of adding pure nutrients to a super maintenance ration of steers. They concluded that the feeding of one kilogram of digestible protein, starch, cane sugar, crude fiber or fat per day resulted in the production of 235 gm., 248 gm., 188 gm., 253 gm. and 474–598 gm. of fat, respectively. Similar experiments with concentrates and roughages showed

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that the digestible nutrients in roughages produced less than the calculated amount of fat.

Turk and associates (35) observed that the biological value of the protein in alfalfa hay was 50 when the hay was fed to lambs whereas the biological value increased to 72 when the hay was supplemented with starch and sugar. Some investigators have reported that the addition of starch or glucose to the ration of ruminants depressed the utilization of some of the nutrients. Robinson (34) found that the addition of 300 grams of starch had no effect on the digestibility of the crude fiber in grass hay or cereal straw but that the addition of 2,270 grams produced a marked depression. The addition of 300 grams of casein to the ration counteracted the effect of the high starch intake. Hart and Humphrey (16) reported that cows receiving a ration of alfalfa hay and corn starch decline in milk production but that production increased when the ration was changed to corn, corn gluten feed and corn stover. Forbes and associates (9) found that the metabolizable energy of a ration containing alfalfa hay and corn was better utilized by a steer than that of a ration of alfalfa hay alone.

Armsby and Fries (1) stated that corn starch has a gross energy value of 4,105 Calories per kilogram of dry matter and Kellner and Köhler (24) reported the value as 4,176 Calories. These investigators also concluded that the addition of starch to the ration of steers decreased the digestibility. The results obtained by Mitchell and associates (29) with calves indicate that the addition of glucose to the ration did not increase methane production although there was a distinct depression in the digestibility of the crude fiber. They reported that the gross energy value of glucose was 3,680 Calories per kilogram of dry matter.

In a preliminary report (17) it was pointed out that when corn, oats, corn gluten meal or barley replaced an isocaloric amount of alfalfa hay in an all alfalfa hay ration of dairy cows, milk production increased markedly. These data were interpreted as indicating a deficiency in alfalfa hay which was corrected by feeding cereal grains or some of their by-products. A long-time study of supplementing an all alfalfa hay ration of cows with corn, oats or barley by the reversal lactation method is under investigation. The object of this paper is to present the results obtained by supplementing the all alfalfa hay ration with corn starch or corn sugar and then replacing these supplements with corn.

## EXPERIMENTAL

The cows used in this investigation were placed on an all alfalfa hay ration at the time of calving and remained on this ration until the reserve factor or factors necessary to complete the alfalfa hay for milk production were exhausted. This was indicated by a sharp drop in milk production which usually occurred within 6 to 10 weeks following calving. When corn starch

or corn sugar was added to the ration, the amount of alfalfa was not reduced unless the appetite became affected. The supplement was placed on the hay and the cows consumed it with relish. It was thought that if the basal ration were deficient in a dietary factor other than available energy then milk pro-

TABLE 1

*Gross energy values of corn starch and glucose as reported in the literature*

| Authority | Heat of combustion | | | T.D.N. |
|---|---|---|---|---|
| | Cal./kg. | Cal./lb.* | Cal./100 lb. | per 100 lb.† |
| **Corn starch** | | | | |
| Atwater (2) | 4,094 | 1,820 | 182,000 | 100.3 |
| Stohmann (2, 12) | 4,123 | 1,870 | 187,018 | 103.1 |
| Stohmann & Langbein (2, 12) | 4,183 | 1,897 | 189,740 | 104.6 |
| Berthelot & Vieille (2, 12) | 4,228 | 1,918 | 191,781 | 105.7 |
| Gibson (2) | 4,164 | 1,889 | 188,878 | 104.1 |
| Stohmann (12) | 4,116 | 1,867 | 186,701 | 102.9 |
| Rechenberg (12) | 4,479 | 2,032 | 203,166 | 112.0 |
| Fingerling *et al.* (8) | 4,061 | 1,842 | 184,206 | 101.5 |
| Loewy (26) | 4,182 | 1,897 | 189,694 | 104.6 |
| Stohmann & Langbein (25, 1) | 4,179 | 1,896 | 189,558 | 104.5 |
| Armsby & Fries (1) | 4,105 | 1,862 | 186,202 | 102.6 |
| Kellner & Köhler (24) | 4,176 | 1,894 | 189,422 | 104.4 |
| DuBois (6) | 4,200 | 1,905 | 190,511 | 105.0 |
| Nakamura (31) | 3,963 | 1,798 | 179,761 | 99.1 |
| Maynard (27) | 4,230 | 1,919 | 191,872 | 105.8 |
| Fraps *et al.* (11) | 4,089 | 1,855 | 185,476 | 102.2 |
| Mean | 4,161 | | | 103.9 |
| 12% moisture | | | | 91.4 |
| T.D.N. on basis of 93% digestibility (apparent) | | | | 85.0 |
| **Glucose** | | | | |
| Berthelot & Vieille (2, 12) | 3,762 | 1,706 | 170,643 | 94.1 |
| Stohmann & Langbein (2, 12) | 3,742 | 1,697 | 169,736 | 93.6 |
| Stohmann (2, 12) | 3,692 | 1,675 | 167,468 | 92.3 |
| Gibson (2) | 3,754 | 1,703 | 170,280 | 93.9 |
| Rechenberg (12) | 3,939 | 1,787 | 178,672 | 98.5 |
| Emery & Benedict (7) | 3,739 | 1,696 | 169,600 | 93.5 |
| DuBois (6) | 3,740 | 1,696 | 169,645 | 93.5 |
| Kharasch (25) | 3,737 | 1,695 | 169,509 | 93.4 |
| Maynard (27) | 3,760 | 1,706 | 170,552 | 94.0 |
| Karrer & Fioroni (23) | 3,743 | 1,698 | 169,781 | 93.6 |
| Huffman & Fox (19) | 3,720 | 1,687 | 168,738 | 93.0 |
| Mitchell *et al.* (29) | 3,680 | 1,669 | 166,924 | 92.0 |
| Mean | 3,751 | | | 93.8 |
| 7% moisture | | | | 87.2 |
| T.D.N. on basis of 93% digestibility (apparent) | | | | 81.1 |

* 2.2046 pounds per kilogram used for conversion.
† 1,814 Calories per pound of T.D.N. (3).

duction would not be materially altered. The supplementary feeding period usually lasted 15 days and this test period was checked against the preceding 15-day lactation period. Fifteen-day periods were used, rather than longer periods, in order to minimize the natural decline in milk production.

In calculating the total digestible nutrient intake, the actual coefficient of digestibility obtained by a digestion trial was used for each hay fed. The requirement figures were calculated according to the standard recommended by Morrison (30). The digestible protein values were also calculated. They are not included with these data but a liberal supply was fed at all times.

Commercial grades of corn starch and corn sugar (glucose) were used. The total digestible nutrient values for these supplements were calculated on the basis of the coefficients of digestion of the dry matter of corn starch reported by Armsby and Fries (1). The same digestibility for the dry matter of corn sugar was assumed. The heat of combustion values reported in the literature for starch and glucose were used as a basis for our calculations. The total digestible nutrient value for starch was calculated on the basis of 12 per cent moisture and on the basis of 7 per cent moisture for glucose. Table 1 presents the gross energy values of these supplements calculated from heat of combustion data recorded in the literature.

The care of the cows and the method used to collect representative milk samples have been reported (18).

## RESULTS

The data obtained from 25 experimental feeding periods on the 14 cows used in this study are presented in tables 2–4. The effects obtained on milk production by supplementing the all alfalfa hay ration with 6 pounds of starch or with 6 pounds of glucose per day are illustrated in table 2. The addition of starch to the ration resulted in a decline in 4 per cent fat-corrected milk in 2 of the 4 trials. Fat production and the test followed the fat-corrected milk. Hay consumption was reduced slightly after the starch was added to the ration (average—1.7 pounds per day). The feeding of 6 pounds of glucose in place of starch gave similar results. Fat-corrected milk declined in 3 of the 6 trials. Glucose decreased the consumption of hay more than the starch (average—5.1 pounds). These results are inconclusive insofar as showing a definite trend in the amount of fat-corrected milk and fat produced but they do illustrate the fact that no marked increase in milk production was obtained by supplementing the alfalfa hay ration with either starch or glucose.

The results obtained by supplementing the alfalfa hay ration with various amounts of starch or glucose followed by increased amounts of starch or glucose or both are given in table 3. The addition of these supplements to the ration resulted in a decrease in 4 per cent fat-corrected milk in all of the trials. When these supplements were increased further, milk production decreased below the previous period in 5 trials and remained unchanged in the sixth. The average yield of fat-corrected milk was 4.2 pounds per day less than that obtained on alfalfa alone. The pounds of fat produced and the test followed the fat-corrected milk. These results show a definite down-

TABLE 2

*Effects obtained in milk production by supplementing an all alfalfa hay ration with 6 pounds of corn starch or with 6 pounds of corn sugar per day**

| Cow No. | Experimental period, days | In milk, days† | Body weight, lb. | Milk, lb. | Test, % | Fat, lb. | F.C.M., lb. | Alfalfa consumed, lb. | T.D.N. | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Rec., lb. | Req., lb. | |
| **Corn starch** | | | | | | | | | | | |
| D14 | 15 | 145 | 1233 | 28.8 | 3.4 | 0.97 | 26.0 | 44.3 | 21.1 | 18.0 | Alfalfa alone |
| | 15 | 160 | 1212 | 28.0 | 3.1 | 0.88 | 24.4 | 42.1 | 25.3 | 17.3 | " plus starch |
| 76 | 15 | 86 | 827 | 19.8 | 3.9 | 0.76 | 19.4 | 29.7 | 14.1 | 13.0 | Alfalfa alone |
| | 15 | 101 | 828 | 20.0 | 3.6 | 0.72 | 18.9 | 28.1 | 18.7 | 12.8 | " plus starch |
| 237 | 12 | 165 | 1118 | 16.1 | 4.2 | 0.68 | 16.6 | 39.4 | 18.1 | 14.1 | Alfalfa alone |
| | 15 | 177 | 1136 | 19.2 | 3.8 | 0.73 | 18.7 | 36.7 | 22.0 | 14.9 | " plus starch |
| 239 | 15 | 38 | 1145 | 27.0 | 3.6 | 0.95 | 25.1 | 36.1 | 15.6 | 17.0 | Alfalfa alone |
| | 21 | 53 | 1156 | 28.1 | 3.6 | 1.01 | 26.5 | 35.9 | 21.8 | 17.6 | " plus starch |
| **Corn sugar** | | | | | | | | | | | |
| 266 | 15 | 185 | 1254 | 26.8 | 3.8 | 1.02 | 26.0 | 44.8 | 21.3 | 18.1 | Alfalfa alone |
| | 21 | 200 | 1277 | 25.8 | 3.9 | 0.99 | 25.2 | 42.7 | 25.8 | 18.0 | " plus sugar |
| A7 | 12 | 185 | 1202 | 19.9 | 3.1 | 0.62 | 17.2 | 40.0 | 18.5 | 14.9 | Alfalfa alone |
| | 12 | 197 | 1260 | 21.3 | 3.3 | 0.70 | 18.9 | 39.6 | 23.8 | 15.7 | " plus sugar |
| A22 | 15 | 88 | 1020 | 27.4 | 3.2 | 0.88 | 24.2 | 36.5 | 19.7 | 15.9 | Alfalfa alone |
| | 15 | 103 | 1015 | 27.1 | 3.3 | 0.90 | 24.5 | 28.2 | 20.0 | 15.9 | " plus sugar |
| D9 | 15 | 194 | 1188 | 16.0 | 3.8 | 0.60 | 15.4 | 36.8 | 17.8 | 14.2 | Alfalfa alone |
| | 15 | 209 | 1157 | 17.2 | 3.7 | 0.63 | 16.4 | 26.3 | 17.3 | 14.3 | " plus sugar |
| 77 | 15 | 44 | 773 | 23.0 | 4.9 | 1.13 | 26.2 | 27.4 | 14.8 | 14.8 | Alfalfa alone |
| | 15 | 59 | 790 | 20.8 | 4.7 | 0.99 | 23.1 | 21.0 | 15.9 | 13.9 | " plus sugar |
| 266 | 15 | 218 | 1222 | 21.1 | 3.6 | 0.77 | 19.9 | 39.7 | 20.4 | 15.9 | Alfalfa alone |
| | 15 | 233 | 1222 | 20.4 | 3.8 | 0.78 | 19.8 | 37.0 | 23.9 | 15.8 | " plus sugar |

* The original data were compiled by 3-day periods whereas the above values represent the mean values obtained for each experimental period.
† At beginning of experimental period.

TABLE 3

*Effects obtained in milk production by supplementing an all alfalfa hay ration with various amounts of corn starch or of corn sugar followed by various amounts of sugar or starch or both**

| Cow No. | Experimental period, days | In milk, days† | Body weight, lb. | Milk, lb. | Test, % | Fat, lb | F.C.M., lb. | Alfalfa consumed, lb. | T.D.N. | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Rec., lb. | Req., lb. | |
| D14 | 30 | 7 | 1271 | 37.1 | 3.0 | ..... | 31.4 | 34.4 | 17.2 | 19.9 | Alfalfa alone |
| | 30 | 37 | 1228 | 33.4 | 3.1 | ..... | 29.1 | 35.0 | 22.5 | 19.3 | " plus 6 lb. starch |
| | 15 | 67 | 1237 | 33.2 | 3.1 | 1.05 | 29.1 | 35.0 | 24.6 | 19.1 | " " 9 lb. sugar |
| 267 | 15 | 16 | 1029 | 27.3 | 3.4 | 0.93 | 24.8 | 36.5 | 17.5 | 16.2 | Alfalfa alone |
| | 9 | 31 | 977 | 24.8 | 3.3 | 0.83 | 22.3 | 35.7 | 20.1 | 15.0 | " plus 3.5 lb. starch |
| | 6 | 40 | 962 | 23.1 | 2.7 | 0.63 | 18.7 | 37.5 | 23.9 | 13.7 | " " 3.5 lb. starch 3.5 lb. sugar |
| 76 | 15 | 27 | 791 | 27.2 | 4.8 | 1.30 | 30.3 | 26.1 | 12.5 | 16.3 | Alfalfa alone |
| | 9 | 42 | 746 | 26.7 | 4.0 | 1.06 | 26.6 | 27.2 | 17.0 | 14.8 | " plus 4 lb. starch |
| | 6 | 51 | 750 | 25.3 | 4.0 | 1.01 | 25.2 | 26.5 | 19.6 | 14.5 | " " 4 lb. starch 4 lb. sugar |
| 77 | 15 | 35 | 725 | 22.9 | 5.0 | 1.14 | 26.2 | 25.0 | 12.0 | 14.5 | Alfalfa alone |
| | 9 | 50 | 680 | 20.4 | 4.9 | 1.00 | 23.2 | 27.1 | 17.5 | 13.2 | " plus 4.5 lb. starch |
| | 6 | 59 | 691 | 20.0 | 4.4 | 0.88 | 21.1 | 26.5 | 20.2 | 12.6 | " " 4.5 lb. starch 4.5 lb. sugar |
| 77 | 12 | 121 | 774 | 18.0 | 5.1 | 0.93 | 21.1 | 26.3 | 12.5 | 13.2 | Alfalfa alone |
| | 12 | 133 | 768 | 17.7 | 4.9 | 0.87 | 20.2 | 26.4 | 18.1 | 12.9 | " plus 6 lb. sugar |
| | 12 | 145 | 767 | 16.9 | 4.8 | 0.82 | 19.0 | 27.6 | 18.4 | 12.5 | " " 6 lb. starch |
| A18 | 18 | 3 | 894 | 20.6 | 4.1 | 0.85 | 22.0 | 28.2 | 13.4 | 14.2 | Alfalfa alone |
| | 12 | 21 | 900 | 22.3 | 3.4 | 0.76 | 20.3 | 26.9 | 15.5 | 13.8 | " plus 3 lb. sugar |
| | 12 | 33 | 889 | 20.9 | 3.0 | 0.62 | 17.7 | 26.9 | 20.6 | 12.8 | " " 3 lb. sugar 9 lb. starch |

* The original data were compiled by 3-day periods whereas the above values represent the mean values obtained for each experimental period.
† At beginning of experimental period.

TABLE 4

*Effects obtained in milk production by supplementing an all alfalfa hay ration with 6 pounds of corn starch or with corn sugar followed with 6 pounds of corn or wheat per day**

| Cow No. | Experimental period, days | In milk, days† | Body weight, lb. | Milk, lb. | Test, % | Fat, lb. | F.C.M., lb. | Alfalfa consumed, lb. | T.D.N. | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Rec., lb. | Req., lb. | |
| **Corn starch** | | | | | | | | | | | |
| A15 | 15 | 27 | 1133 | 31.3 | 3.0 | 0.93 | 27.3 | 34.7 | 17.9 | 17.5 | Alfalfa alone |
| | 15 | 42 | 1155 | 28.3 | 3.1 | 0.87 | 24.4 | 32.8 | 22.3 | 16.9 | " plus starch |
| | 18 | 57 | 1119 | 31.5 | 3.2 | 1.02 | 27.8 | 30.0 | 20.3 | 17.8 | " " corn |
| A22 | 15 | 188 | 1032 | 18.4 | 3.6 | 0.66 | 17.2 | 40.0 | 20.2 | 13.7 | Alfalfa alone |
| | 15 | 203 | 1035 | 18.1 | 3.5 | 0.63 | 16.8 | 39.2 | 25.1 | 13.6 | " plus starch |
| | 18 | 218 | 1024 | 21.1 | 3.4 | 0.71 | 19.2 | 40.0 | 25.1 | 14.4 | " " corn |
| A31 | 15 | 134 | 782 | 17.1 | 3.5 | 0.59 | 15.7 | 27.8 | 12.8 | 11.5 | Alfalfa alone |
| | 15 | 149 | 792 | 18.4 | 3.5 | 0.64 | 16.9 | 24.6 | 16.7 | 12.0 | " plus starch |
| | 27 | 164 | 811 | 22.3 | 3.5 | 0.79 | 20.7 | 24.7 | 16.2 | 13.3 | " " corn |
| 76 | 15 | 49 | 792 | 22.0 | 3.3 | 0.74 | 19.8 | 25.0 | 12.6 | 12.9 | Alfalfa alone |
| | 51 | 64 | 794 | 22.8 | 4.1 | 0.93 | 23.2 | 25.0 | 17.9 | 14.0 | " plus starch |
| | 18 | 115 | 841 | 22.1 | 4.5 | 1.00 | 23.8 | 25.0 | 17.5 | 14.5 | " " wheat |
| 237 | 15 | 118 | 1143 | 21.2 | 3.6 | 0.76 | 19.8 | 40.0 | 20.2 | 15.5 | Alfalfa alone |
| | 15 | 133 | 1147 | 19.9 | 3.4 | 0.68 | 18.1 | 39.0 | 25.1 | 14.9 | " plus starch |
| | 21 | 148 | 1139 | 20.7 | 3.8 | 0.78 | 20.0 | 35.0 | 22.5 | 15.4 | " " wheat |
| **Corn sugar** | | | | | | | | | | | |
| A15 | 15 | 137 | 1034 | 24.6 | 3.6 | 0.87 | 23.0 | 44.8 | 20.7 | 15.6 | Alfalfa alone |
| | 15 | 152 | 1040 | 27.3 | 3.4 | 0.92 | 24.8 | 43.0 | 25.5 | 16.2 | " plus sugar |
| | 18 | 167 | 1060 | 32.7 | 3.3 | 1.06 | 29.3 | 44.1 | 25.2 | 17.7 | " " corn |
| A18 | 15 | 134 | 1179 | 25.9 | 3.6 | 0.92 | 24.1 | 39.8 | 18.4 | 17.0 | Alfalfa alone |
| | 15 | 149 | 1175 | 24.8 | 3.7 | 0.92 | 23.7 | 33.9 | 20.5 | 16.8 | " plus sugar |
| | 15 | 164 | 1169 | 27.5 | 3.5 | 0.97 | 25.5 | 34.4 | 20.7 | 17.3 | " " corn |
| 266 | 15 | 44 | 1191 | 37.5 | 3.3 | 1.22 | 33.3 | 42.1 | 21.7 | 20.1 | Alfalfa alone |
| | 18 | 59 | 1210 | 41.4 | 3.2 | 1.33 | 36.5 | 38.0 | 24.4 | 21.2 | " plus sugar |
| | 15 | 77 | 1227 | 43.7 | 3.2 | 1.38 | 38.2 | 35.8 | 23.1 | 21.9 | " " corn |
| 266 | 15 | 131 | 1235 | 25.9 | 4.1 | 1.06 | 26.3 | 43.5 | 22.4 | 18.1 | Alfalfa alone |
| | 15 | 146 | 1215 | 25.8 | 3.9 | 1.02 | 25.6 | 36.0 | 23.4 | 17.6 | " plus sugar |
| | 15 | 161 | 1223 | 30.5 | 3.3 | 1.00 | 27.2 | 33.9 | 22.3 | 18.3 | " " corn |

* The original data were compiled by 3-day periods whereas the above values represent the mean values obtained for each experimental period.
† At beginning of experimental period.

ward trend in milk production, fat and test after the alfalfa hay ration was supplemented with starch or glucose or a combination of both. Increasing the amounts of these supplements in the ration did not influence the natural decline in milk production with advancing lactation. Insofar as starch and glucose are concerned they were unable to change the course of lactation in these cows. Hay consumption was decreased slightly after the starch or glucose was added to the ration (average—0.3 pounds per day). When the amount of starch or glucose was increased or combined, there was a further reduction in hay consumption (average—0.3 pounds per day) over the preceding trial.

The results obtained from supplementing the alfalfa hay ration with 6 pounds of starch or glucose and then substituting 6 pounds of corn or wheat for the starch or glucose are presented in table 4. The addition of starch resulted in a decline in 4 per cent fat-corrected milk in 3 out of 5 trials. The fat production and percentage test followed the fat-corrected milk. When the starch was replaced with 6 pounds of corn or wheat, the fat-corrected milk increased against the tide of declining lactation in all trials. The average increase was 2.4 pounds per day over the starch feeding period and 2.3 pounds per day over the all alfalfa hay ration. The average of a 15-day period when either corn or wheat was fed does not do justice to the fat-corrected milk values reported in table 4 because about 6 days were usually required for the cows to reach the peak of production after the cereal grains were fed. The fat production and the test again followed the fat-corrected milk. The average hay consumption declined 1.4 pounds per day after the starch was added to the ration and decreased 1.2 pounds per day further after the corn or wheat replaced the starch supplement.

The addition of glucose to the alfalfa ration resulted in a decline in 4 per cent fat-corrected milk in 2 out of 4 trials. When glucose was replaced with 6 pounds of corn, milk production, fat and test increased in all trials. The average increase in fat-corrected milk was 2.4 pounds per day over the glucose feeding period and 3.4 pounds per day over the all alfalfa hay ration. The average daily hay consumption for this group of cows decreased 4.8 pounds after the glucose supplement was added to the ration and decreased 0.7 pounds per day further when corn replaced the glucose supplement.

The results obtained with Cow 266 (table 4) are of interest. When 6 pounds of glucose were added to the hay ration on the 56th day of lactation, the average daily increase in fat-corrected milk was 3.2 pounds for the 18-day period. Later in the same lactation period (149th day), the addition of 6 pounds of glucose resulted in a decrease in fat-corrected milk. In all probability the increased production of milk during the first trial was due to the carry-over effect from the dry period. In other words, the cow had not been depleted of the milk-stimulating factor or factors.

It is evident from all of these trials that supplements of starch and glu-

cose are ineffective in producing marked increases in milk production in cows on an all alfalfa hay ration. The replacement of these supplements with either corn or wheat, however, results in an appreciable increase in 4 per cent fat-corrected milk. The fact that both corn and wheat stimulated milk production against the tide of declining lactation suggests that these cereals furnish a factor or factors other than digestible calories. Milk production decreased in 9 trials and increased in 4 trials when starch supplemented the hay ration. The average decline in fat-corrected milk was 0.81 pounds per day. Milk production decreased in 7 trials and increased in 5 trials when glucose supplemented the hay ration. The average increase in fat-corrected milk was 0.02 pounds per day. The fat production and the test followed the fat-corrected milk very closely in nearly all cases. The average body weight changes varied less than $\pm 1$ per cent for all of the trials. The alfalfa-starch ration caused a slight decrease in body weight, whereas, the alfalfa-glucose ration caused a slight increase. The changes in body weight, however, were insignificant. The addition of 3 to 9 pounds of starch or glucose to the alfalfa hay ration did not produce a significant change in alfalfa consumption although the dry matter intake was increased. Hay consumption decreased in 9 trials, increased in 3 trials and was unchanged in 1 trial. The average decrease in hay consumption on the alfalfa-starch ration was 0.8 pounds per day. Hay consumption decreased in 11 trials and increased in 1 trial on the alfalfa-glucose ration. The average decrease was 4.2 pounds per day. Dry matter intake increased when the starch and glucose supplements were fed to the cows but the starch-fed cows showed a greater increase than the glucose-fed cows.

## DISCUSSION

It has been reported previously (17, 18) that the replacement of an equal amount of total digestible nutrients in alfalfa hay with corn in the ration of lactating cows, which had been depleted on alfalfa hay alone, resulted in a marked increase in milk production against the tide of decline in lactation. Supplementing the all alfalfa hay ration with cystine had little influence on lactation (18). This study shows the effects of supplementing the all alfalfa hay ration with calories fed in the form of corn starch or corn sugar. Kellner and Köhler's (24) early work indicated that the addition of starch to a maintenance ration of steers resulted in good utilization of starch for gain in fat. Our results show that starch and glucose failed to influence milk production significantly in cows that had been depleted of their milk-stimulating factors. When the cows had not been entirely depleted on alfalfa alone or when ketosis was involved, the feeding of starch and glucose stimulated milk production.

In table 4, cows A15, A22 and A31 produced 3.4, 2.4 and 3.8 pounds of 4 per cent fat-corrected milk per day more when 6 pounds of corn re-

placed 6 pounds of starch. Significant increases in milk production were obtained also when 6 pounds of wheat replaced the starch. The total digestible nutrients received during the corn- and wheat-feeding periods were the same for 3 cows but were slightly less for the other 2 cows. Cows A15, A18 and 266 produced 4.5, 1.8, 1.7 and 1.6 pounds of 4 per cent fat-corrected milk more per day when 6 pounds of corn replaced 6 pounds of glucose. The total digestible nutrients received during the corn-feeding periods were about the same as during the glucose-feeding periods. These data indicate that corn furnishes some factor or factors, other than calories, needed to balance an all alfalfa hay ration.

The productive energy value of feeding stuffs depends on the balance of the ration. Many authorities have used either the total digestible nutrients system or some method of calculating the so-called "productive energy," "net energy" or "starch value" of feeds. The starch value system suggested by Kellner (24) was based on his work with a respiration calorimeter. These values indicate that a pound of total digestible nutrients in concentrates was better utilized than an equal amount in roughage. Forbes *et al.* (9) observed that the metabolizable energy of a ration of alfalfa hay and corn was much better utilized than alfalfa hay alone. Fraps and Carlyle (10), using a corn and casein replacement method, concluded that the ability of the chicken to utilize the digested material is quite uniform. When the balance of the ration is taken into consideration there appeared to be little difference in the productive power of the digestible nutrients for fattening.

The data presented in this paper indicate that the reason for the low productive power of the all alfalfa hay ration was not due to a lack of digestible calories but that the inferior value of the total digestible nutrients in the alfalfa was due to a lack of the necessary dietary factors. Corn and wheat apparently furnish dietary factors other than calories which are not supplied in sufficient quantities in alfalfa hay for lactation. The data in the literature suggest that early cut hay is higher in the unknown factors supplied by grain than later cut hay.

The increase in milk production obtained by replacing starch or glucose with corn or wheat may be due to presence of a more favorable food for the microorganisms in the rumen. Mills and associates (28) found no evidence of increased microbiological activity in the rumen contents when starch was added to a ration of timothy hay. When urea and starch supplemented the hay, a suitable substrate was provided for the development of an active flora. There is a possibility that the flora and fauna in the rumen of the cows fed alfalfa alone were unable to synthesize the dietary factors needed for optimum milk production. The work of Hunt *et al.* (20) indicates that there was no riboflavin synthesized in the rumen of the steer on alfalfa hay alone but that synthesis increased as the amount of corn in the ration increased. Ground corn appeared to have a more favorable effect than whole corn. The amount of carbohydrate in the ration may stimulate riboflavin synthesis.

The feeding of starch as a supplement to an all alfalfa hay ration did not depress the appetite for hay significantly under the conditions of this experiment. The average daily consumption of alfalfa alone was 33.8 pounds against 33.0 pounds when starch was added to the ration. The cows which received glucose consumed 33.3 pounds of alfalfa daily and 37.5 pounds on alfalfa alone. These data suggest that glucose tends to depress the appetite for hay to some extent but that starch has very little effect on hay consumption. The effect of glucose on appetite may be explained on the basis of rapid absorption from the rumen or, since this sugar is highly soluble, a large portion may have been washed rapidly through the true stomach and then absorbed from the small intestine. Phillipson and McAnally (32) demonstrated that the administration of glucose or cane sugar to a fistulated sheep caused an intense fermentation and a rapid fall in pH in the rumen during the first hour. No such reaction occurred after the administration of starch or cellulose.

## SUMMARY

1. The effect of supplementing an all alfalfa hay ration with either corn starch or corn sugar (glucose) was studied on 25 feeding trials with 14 cows. Six pounds of starch or glucose were usually added per day.

2. The addition of starch or glucose to the alfalfa ration did not increase the production of fat-corrected milk although the total digestible nutrient intake was increased appreciably.

3. The replacement of 6 pounds of starch or glucose with 6 pounds of corn or wheat increased the production of fat-corrected milk markedly although the total digestible nutrient intake was not increased.

4. The addition of starch to the alfalfa ration did not reduce the appetite for hay but the addition of glucose tended to depress hay consumption.

5. The results of these experiments indicate that digestible calories are not the limiting factors in alfalfa hay for optimum milk production but that an unknown milk-stimulating factor or factors are supplied by corn or wheat when fed as a supplement to an all alfalfa hay ration.

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# A STANDARD FOR EVALUATION OF DAIRY SIRES PROVED IN DAIRY HERD IMPROVEMENT ASSOCIATIONS*

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Dairy cattle are bred primarily for milk production, a character manifested in only the female sex. The males, however, carry the genetic factors determining ability to produce milk and the male parent exerts an influence essentially equal to that of the female upon the productive ability of the female offspring. Due to the relatively large number of offspring he leaves in the herd, the selection of the herd sire is a matter of great consequence. Since an outward expression of inherent productive ability is lacking in the bull, this must be evaluated largely upon the basis of the performance of related females. It is generally recognized that the future breeding worth of a dairy sire can best be evaluated on the basis of progeny which have reached producing age. There are many practical limitations to the general use of progeny-tested sires but in evaluating a pedigree some of the most valuable information is secured from the performance of progenies of the male ancestors. Consequently, proper evaluation of progeny tested bulls must be recognized as a matter of great importance in the breeding of dairy cattle.

Unfortunately, even though a bull may have daughters which have been tested for production, evaluation of his transmitting ability is not easy and predictions of his future breeding worth are likely to be of questionable reliability. Environmental conditions make tremendous differences in the degree to which a cow can express her inherited ability to produce. While reasonably satisfactory correction factors have been developed for some of these, there remain many non-genetic influences which cannot be equalized, and which introduce an element of uncertainty into any rating based upon poduction records. The principal problems of evaluating a bull on the basis of production of his progeny arise from the fact that he contributes only half of the gene complex of his offspring. Unless the contribution of the female parents can be correctly estimated, such evaluation on the sire has limited value. Many workers in the field of dairy cattle breeding have endeavored to arrive at a single index or a figure representing the potential productive

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ability of a progeny tested sire. Lush (2) has presented a very comprehensive discussion of the sire index question. The most commonly used and perhaps the oldest of these proposed indexes is based on the assumption that the offspring will tend to be intermediate in productive ability between that of the dam and the potential productive ability of the sire. Such a tendency is observed in the case of characters determined by multiple genetic factors and has been recognized for many years. Having a measure of any two of the animals of the parent-offspring trio, the productive ability of the third can be estimated. Ordinarily the male parent is the unknown of the equation, but once his capacity is established, his future daughters become the unknown in considering the use of the bull in a program of breeding. The most common form of this index, assuming exact intermediate inheritance, is known under various names such as equi-parent, equal parent, mid-parent, or intermediate index. A number of other indexes have been suggested, for the most part trying to make allowances for the unreliability of the production of the dams as a basis for estimating their contribution to their offspring and for the tendency for regression toward the breed average.

Theoretically, a satisfactory sire index should rate the bull the same, regardless of the productive level of the dams of his progeny, since the purpose of the index is to eliminate the influence of the dams and measure that of the sire alone. That the commonly used indexes fail in this respect has been concluded by a number of investigators from studies in which progenies of sires with large numbers of offspring were divided and the index was calculated separately on each portion of the progeny. It was found in each case that there was less variation between the simple averages of the progenies of the two groups than between the indexes calculated from comparisons with the dams. On this basis it has been suggested that the best measure of a bull's breeding worth is a simple average of the production records of his daughters, with due correction for non-genetic factors. This should not be interpreted, however, as meaning that the dams' records have no value for improving the accuracy of evaluation of breeding worth of progeny tested sires. It has repeatedly been shown that there is a definite correlation between records of daughters and of dams.

It is to be observed in those studies in which the dams were divided on the basis of productive levels there was a tendency for the average production of daughters from the higher producing dams to be above that of the daughters from the lower producing dams. This lends support to the belief that the records of the dams do have potential value in evaluating progeny tested sires, but that they may not be properly employed in the indexes studied, introducing greater errors than the error of disregarding entirely the information on the dams. In the studies cited, the method of dividing the progeny according to production of dams is subject to criticism, since the dams of the higher level will tend to include those favored by environment

and the errors of sampling as well as those genetically superior. Furthermore, it is highly probable that in a majority of the cases all or most of the daughters occurred in the same herd and that they and their dams were exposed to similar environmental conditions. Under such circumstances it is reasonable to expect that future daughters of the sire, from the same or closely related dams and exposed to very similar environment would resemble closely the previous daughters in productivity, and that any inherent errors of proposed indexes would reduce rather than improve the accuracy of a prediction of production of these future daughters. Certainly the simple average of the daughters' production would have very limited value in predicting production of future daughters under different environment. Nor would the equi-parent or similar indexes be expected to be much more satisfactory under such conditions.

The fact that the genetic make-up of the cows to which a bull is mated will influence the production of his daughters is axiomatic. Any index which takes no account of the contribution of the female parents is obviously omitting a matter of very serious consequence which, if it could be evaluated properly, would add to the accuracy of the final index. Unfortunately no entirely accurate measure of the contribution of the female parents is available, but this fact should not discourage the use of any measure which would materially increase the accuracy of the estimate.

It has long been recognized that the progeny of cows above the average productive ability of the breed tend to produce above the breed average but less than their dams. and that daughters of cows below the breed average tend to produce below the breed average but not as far below as their dams. Formulas for estimating expected performance of daughters on the basis of performance of dams have been worked out from various data and reported by different workers. This tendency of regression toward the breed average has been taken into account in the derivation of some of the formulas proposed for use in arriving at an index of breeding worth of proved dairy sires. While some of these appear to have definite merit, they have failed to meet with popular favor, possibly because they are not fully understood by those not mathematically inclined.

Norton (3) has suggested an index based upon this principle, but given in terms easily understood by the average breeder. He selected from the Holstein Advanced Registry, those cows whose dams also had advanced registry records. Their records for fat yield and those of the dams were corrected for age, number of milkings, and length of record. The daughters were then grouped according to the average butterfat production of the dams and an "expectancy table" was worked out showing the average production of daughters from dams of the various levels. This table is used as the basis for a proposed sire index. Instead of comparing the average production of the bull's progeny to that of their dams, Norton proposed

that it be compared to the expected production as indicated in his table of average experience or expectancy. He proposed that the difference between actual and expected production of the daughters be added to if greater, or, if lower subtracted from the average production of the daughters. This is the same as adding to the expected production, twice the deviation from expectancy, or an application of the equal parent principle with the expected production as a base.

The fundamental idea of the expectancy table seems very sound and practical, applying the principle of regression in a workable and easily understood manner, but the application suggested by Norton does not appear entirely logical. The production of the daughters, and the expected production, are influenced by the dam as well as the sire, and when the deviation from expected production is added to the production of the daughters, a rating is secured from which the influence of the dams has not been excluded, and which is not directly comparable to a rating secured on dams of a different average level of production.

Since a large number of sires is included, it is probable that the sires throughout the group will on the average be genetically approximately an average group of bulls for the breed. Moreover, it seems logical to assume that the average bull of a breed will have a genetic make-up of factors for productive ability essentially equivalent to that of the average cow. Therefore, it might be assumed that a bull whose daughters on the average reach only the level of the expectancy table is a bull with the average genetic make-up of his breed and that his potential productive ability is equivalent to the average production of females of the breed. The soundness of this assumption is borne out by the fact that the point at which the daughters average the same as the dams agrees closely with the average of the entire group. Below this level, the daughters tend to be superior to their dams, but above this level the daughters tend to be inferior, suggesting that the average effectiveness of the selection of bulls has not been very great.

It would, therefore, seem reasonable, if an index is desired expressing the potential productive ability of a sire under average environment based on the equal parent assumption, to double the deviation of his daughters from expectancy and add to the breed average for potential performance of sires, represented by the level at which daughters and dams are equal. This index is based on a definite environmental level, with the influence of the dams standardized, or merely Norton's index transposed to an average set of conditions. This treatment renders the index more suitable for comparing directly, ratings on different sires. Even if no attempt is made to arrive at a single expression of the sire's potential productive ability, the expectancy table should be exceedingly valuable as a practical standard of comparison or a "par" value by which to judge proved sires.

The publication of the results of the Nation-wide survey of dairy sires

proved in dairy herd improvement associations by the Bureau of Dairy Industry of the United States Department of Agriculture has provided a large volume of data from which expectancy tables may be derived for our five major dairy breeds under average Dairy Herd Improvement Association conditions. Being based upon progeny groups rather than individual daughter-dam pairs it should be even more useful as a standard for evaluating sire performance. It is felt that a table of average performance of this large group of sires, arranged by breeds, and according to average level of dams for milk yield, fat yield, and fat percentage should provide a very

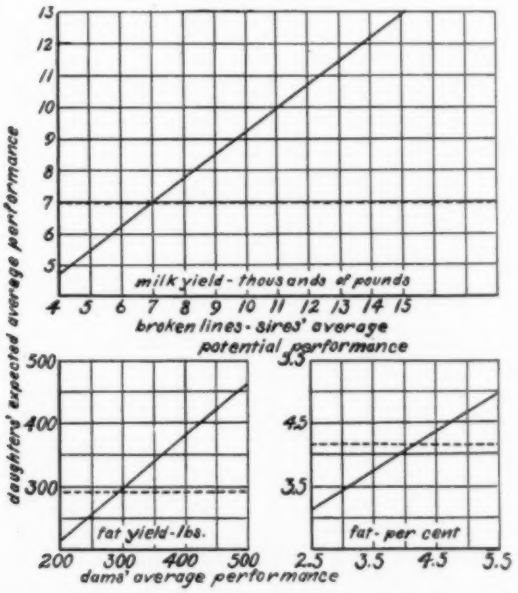


FIG. 1. Average performance of 214 Ayrshire sire progeny groups as related to level of performance of their dams.

valuable standard of comparison for evaluating proved sires. With this thought in mind, this study was undertaken.

The Division of Dairy Herd Improvement Investigations of the Bureau of Dairy Industry of the United States Department of Agriculture (1) has compiled the data gathered in the Nation-wide program of proving dairy sires which has been carried out in cooperation with the dairy extension service in the various states. This has made available daughter-dam comparisons for 5886 sires of the five major dairy breeds and provides a wealth of data for study of the performance of dairy sires under Dairy Herd Improvement Association conditions. The data for each breed have been con-

sidered separately. Duplication of sires has been avoided, using only the latest or most complete data for sires appearing in more than one of these published lists.

These data have been assembled according to the average performance of the dams to which the individual sires were mated. Milk production, fat production, and fat percentage have been considered separately. From these data for each breed and for each of the three performance factors the average level of performance of the sires' progenies has been estimated in relation to the average level of the dams to which they were mated. The

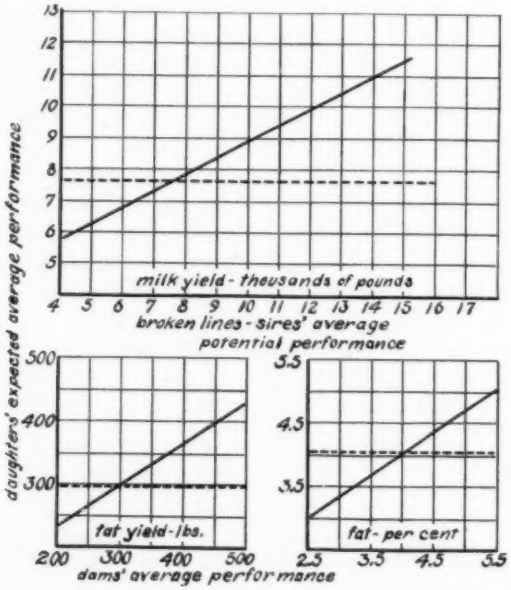


FIG. 2. Average performance of 124 Brown Swiss sire progeny groups as related to level of performance of their dams.

data have been fitted by the method of least squares and are presented graphically in figures 1 to 5 inclusive. In table 1 the comparative average performance of daughters and dams for the entire group is shown, together with the formula for estimating expected production of the progeny.

At the outset, it must be recognized that the progenies in the higher level of production will tend to have an average environment more favorable than those in the lower levels and the widest range of environment will fall in the median group. In all probability in the lowest levels are found the poorer animals genetically, and handled under the poorest conditions. In the highest levels will be found those with the highest genetic productivity

handled under the most favorable conditions. In the intermediate groups will be found animals of good heredity limited by poor environment and animals of relatively poor heredity but with favorable environment as well as animals of average heredity and average environment. It is also probable that more care has been exercised in selection of sires used on the dams of the higher levels of production and that there is some degree of hereditary superiority as compared to the sires used at the lower levels. The best prediction for a bull for continued use in the herd where he was proved should

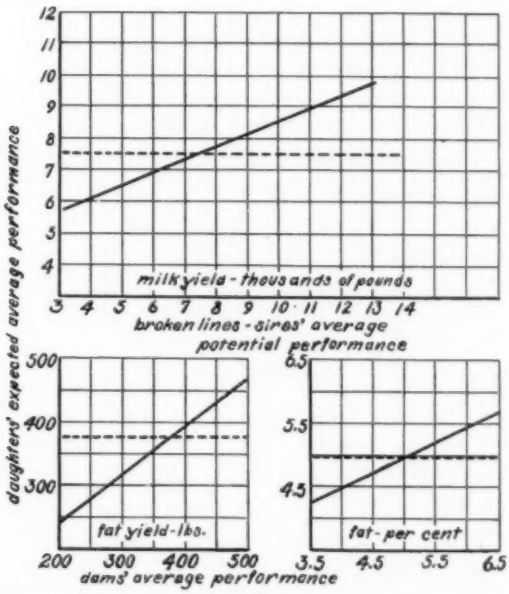


FIG. 3. Average performance of 1238 Guernsey sire progeny groups as related to level of performance of their dams.

be the simple average of his daughters, since his future daughters will be largely from the same group of dams and under very similar environment. Almost any index when used to forecast probable production of future daughters of the same dams would predict a production the same as for the previous daughters. For predicting his future daughters from a group of dams in another herd where both the hereditary contribution of the dams and the environment are different, a standard such as the expectancy formula given in this paper should have much greater value, provided the records are arrived at in the same manner as in those from which the standard is derived, *i.e.*, lifetime average, Dairy Herd Improvement Association, 305-day, mature, twice a day milking basis.

A study of the data in table 1 shows that except in the case of the Guernsey group, the level at which the daughters equal their dams in milk production is somewhat below the average for the breed. This suggests that the culling practiced in the cows is more effective than the selection of the sires, with either more effective selection of sires or less effective culling of cows, or both in case of the Guernsey group. Likewise in fat production the Holstein, Ayrshire, and Brown Swiss bulls failed to maintain production up to the breed average while the Guernsey and Jersey bulls maintained production slightly above the breed average. For butterfat percentage

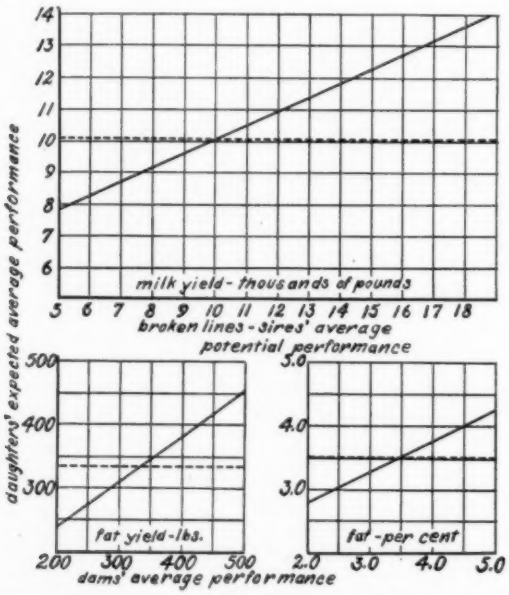


FIG. 4. Average performance of 3322 Holstein sire progeny groups as related to level of performance of their dams.

which is merely an expression of the relationship between milk yield and fat yield, in all breeds the sires were able to maintain a level higher than the average for the breed. This might be due to culling out the lowest milk producers among the cows. The poorest milk producers are likely to have a fairly high test due to an inverse relationship at lower levels of milk production.

The average milk production of the daughters is less than of the dams in all but the Guernsey breed, and average fat production is less in all except the Guernsey and Jersey breeds. The average production of the daughters will usually tend to be lower than of the dams in studies of large numbers

since the dams are influenced more by selection and culling. A cow that has a low yield for her first lactation is not likely to have a further opportunity to become a dam, since she will probably be culled from the herd. A situation in which the daughters equal the dams in average production over a period of years will result in a gradual increase in productivity for the population since such an increase will be necessary to mask the influence of differential selection and culling.

The correlation between daughters and dams is greater for fat yield than for either milk yield or fat percentage. This cannot be attributed entirely

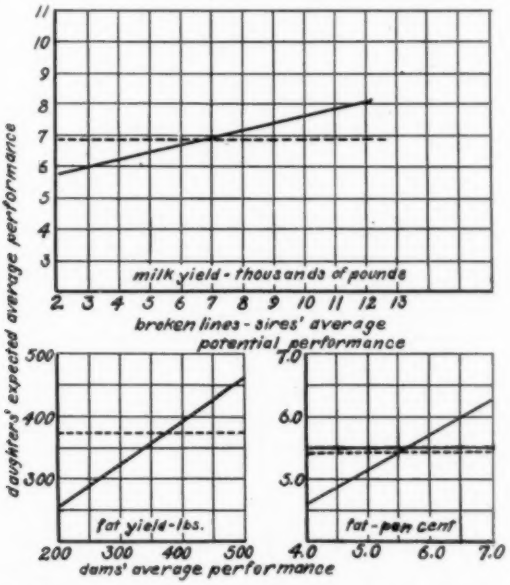
daughters' expected average performance
milk yield - thousands of pounds
broken lines - sires' average potential performance
fat yield - lbs.
fat - per cent
dams' average performance

FIG. 5. Average performance of 988 Jersey sire progeny groups as related to level of performance of their dams.

to a greater degree of heredity as compared to fat percentage, however, since the daughters and dams tend to have similar environment and the fat percentage is influenced to a much lesser degree by environment. The Mount Hope index is applied to milk yield and to fat percentage. The equal parent index is in many cases likewise applied, the index for fat yield being the product of the indexes for milk yield and fat percentage. There are many reasons both genetic and physiological for believing that such indexes might more properly be applied to fat yield than to fat percentage.

Although the equal parent or any similar index will undoubtedly differentiate between extremes of potential productive ability, a relative rating

of two bulls based on the index alone with no knowledge of the figures from which the index was derived may be misleading.

While a modification of Norton's index has been suggested, based on a comparison of actual and expected production, it is not recommended that such an index be used in rating sires unless the data used in arriving at the index are included. A single figure such as this is apt to create an impression of greater accuracy than actually exists. It is felt that the greatest practical value of the expectancy tables lies in their use as a standard of

TABLE 1

*Relationship of production of daughters of sires proved in Dairy Herd Improvement Associations to production of their dams*

| Breed | No. of sires | Average performance daughters | Average performance dams | Sires' average potential performance* | Formula for expected performance of daughters |
|---|---|---|---|---|---|
| | | Milk yield, pounds | | | |
| Ayrshire | 214 | 7,821 | 8,103 | 6,980 | 1,752 + (.7490 × dams') |
| Br. Swiss | 124 | 8,404 | 9,090 | 7,655 | 3,659 + (.5221 × dams') |
| Guernsey | 1,238 | 7,530 | 7,462 | 7,578 | 4,427 + (.4158 × dams') |
| Holstein | 3,322 | 10,414 | 10,769 | 10,135 | 5,672 + (.4403 × dams') |
| Jersey | 988 | 6,935 | 7,160 | 6,865 | 5,226 + (.2387 × dams') |
| | | Fat percentage | | | |
| Ayrshire | 214 | 4.035 | 3.964 | 4.144 | 1.658 + (.5998 × dams') |
| Br. Swiss | 124 | 4.024 | 3.981 | 4.113 | 1.362 + (.6688 × dams') |
| Guernsey | 1,238 | 4.872 | 4.787 | 4.951 | 2.563 + (.4825 × dams') |
| Holstein | 3,322 | 3.473 | 3.436 | 3.510 | 1.775 + (.4945 × dams') |
| Jersey | 988 | 5.294 | 5.195 | 5.415 | 2.435 + (.5503 × dams') |
| | | Fat yield, pounds | | | |
| Ayrshire | 214 | 316.1 | 320.9 | 292.4 | 49.2 + (.8317 × dams') |
| Br. Swiss | 124 | 338.1 | 361.4 | 296.7 | 106.6 + (.6407 × dams') |
| Guernsey | 1,238 | 360.7 | 356.2 | 375.6 | 86.8 + (.7690 × dams') |
| Holstein | 3,322 | 359.2 | 369.4 | 335.4 | 100.4 + (.7006 × dams') |
| Jersey | 988 | 366.7 | 364.4 | 371.8 | 115.2 + (.6903 × dams') |

* The average potential performance of the sires is the level at which the average performance of the daughters equals that of their dams.

comparison by which to interpret the differences in production of progeny as compared to their dams. By the equal parent or similar indexes, when the bull is rated on the basis of extremely high producing dams, environment for both daughters and dams is almost certain to be very favorable. If this index is used to estimate the probable production of daughters in a herd of very low production where environment is apt to be very poor, the daughters will probably fall far short of the estimate. Likewise a bull used on dams of poor production, with daughters tested under the same environment, will probably be underrated for use in herds of high production. This

tendency might be offset to some degree by the greater assertion of the influence of dominant genes at lower levels of production. If a bull is rated on the basis of deviation of his daughters from expected production (using the expectancy tables for the breed as a standard) there may be a similar tendency but to a lesser degree since only the spread is affected. The base is a variable in which cognizance is taken of the difference in environment.

An index giving a specific rating on a bull is in itself of value only in making a choice between bulls. In the final analysis the factor of greatest importance is the accuracy with which production of future daughters may be predicted. This involves essentially a reversing of the process of calculating the bull's index. If this prediction is for future daughters in the same herd from the same dams, regardless of what index is used, the prediction will be the same as the average production of the daughters. For predicting production in a herd where environment and heredity of the dams are different, the index should make allowance for these differences. When used for predicting production of future daughters, the simple equal parent index does not make allowance for the differences in environment.

The suggested modification of Norton's index in which twice the deviation of daughters is added to the breed average for sires' potential performance should be more suitable for a comparative rating of sires, since environment is at least partially standardized and there is no regression at the level of production and environment for which the index is calculated. For calculating the probable production of future daughters, this index of the sire is not needed, only the deviation from expectancy being used. The average expected production may be estimated for the dams on which the bull is to be used. This gives a base in which differences both genetic and environmental are considered. To this base, the deviation of the bull's previous progeny from expectancy may be added to secure an estimate of probable production of future progeny. In doing this, a deviation below expectancy must, of course, be treated as a negative quantity. In the final analysis, this is nothing more than the equal parent index with compensation for differences in environment and for regression. By using the charts to determine expectancy, this method can be applied with no more calculation than a simple addition or subtraction.

Naturally, such a method will not fit all individual cases, but there is reason to believe that with no loss of simplicity, the average degree of accuracy should be greater than for the simple equal parent index. While no method gives a strictly accurate estimate, any method which increases the average degree of accuracy has practical value until a better is offered. These charts or formulas can be properly applied only to cases within the range of conditions of the population from which they were derived. For advanced registry conditions, a similar standard should be worked out from advanced registry data.

If accompanied by an adequate testing and record keeping program, artificial insemination associations should in a few years provide data ideally suited for a critical study of the comparative value of various bull indexes, with a possibility of arriving at a more accurate method of rating progeny tested sires than any yet suggested. While no method gives an entirely accurate estimate, any method which increases the average accuracy is desirable.

## SUMMARY

1. From the lists of sires proved in dairy herd improvement associations, compiled by the Bureau of Dairy Industry, formulas have been derived for estimating the average expected production of daughters according to the productive level of the dams.

2. This average expected production of milk, of fat, and for fat percentage is presented in graphical form, to be used as a guide in evaluating progeny tested bulls and in predicting probable production of future daughters.

3. A modification of Norton's sire index is suggested for comparative rating of sires. Twice the deviation of the sire's daughters' production from the expected is added (negative deviations carrying a minus sign) to the breed average for potential performance of sire to give an estimate of the sire's hypothetical productive ability under average environment for the population.

4. To estimate probable production of future daughters, the deviation of his daughters' production from expected is added (deviations below expected being treated as negative values) to the expected production estimated for daughters of the cows to which he is to be mated.

5. This method applies the equal parent principle with a simple and workable allowance for regression and general differences of environment.

## NOTE

Subsequent to the preparation of the manuscript for this paper, Rice (4, 5), has published a report of a study of the performance of Ayrshire sires whose provings were available in the records of the Ayrshire Breeders' Association. As a result of his investigation, he has suggested a method for evaluating progeny tested sires based on the same fundamental concepts as proposed in this paper.

Rice's proposed index differs in principle from that suggested in this paper in that he does not double the deviation from expected production before adding to the breed average. If the index is intended to represent the potential productive ability of the sire, the same principle of regression which is fundamental to the entire proposal suggests that this deviation should be doubled. In the simplified application based on fifty per cent

regression, this is identical to the ordinary equal parent index. As used by Rice, it differs by the amount of the deviation from expected production, being higher by this amount for bulls whose daughters fall below and lower for those whose daughters exceed expectancy. For predicting the performance of future daughters, which is the ultimate purpose of a sire index, the predicted production based on fifty per cent regression will be the same as if the simple equal parent method had been used, regardless of whether or not the deviation is doubled. This method of evaluating sires and predicting the performance of future daughters is an improvement over the ordinary equal parent procedure only to the extent that the regression varies from a value of fifty per cent, and any additional practical value which it may have is lost if the actual regression is rounded to fifty per cent.

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# THE RATIO OF ASCORBIC, NICOTINIC, AND PANTOTHENIC ACIDS, RIBOFLAVIN AND THIAMIN IN LATE SUMMER MILK*

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Since milk serves as the sole nourishment of the young of the various species of animals that produce it, some have considered it a complete food, at least for young animals. Accordingly, many studies have been conducted to determine its nutritive value, and years ago data were accumulated concerning the minerals, protein, fat, and fatty acids which occur in cow's milk. During the discovery of vitamins or food accessory factors, as they were then designated, Hopkins (9), Osborne and Mendel (21), McCollum and Davis (15) and others found that cow's milk was a good source of the early recognized fat- and water-soluble vitamins. Langworthy and Holmes (13) found that milk fat was practically completely utilized by the human body. With the continuous accumulation of data concerning its nutritive value, the importance of milk as a human food has been constantly emphasized. However, recently additional water-soluble vitamins have been discovered and identified. Therefore additional data are required for a more complete evaluation of milk as a human food and particularly to enable one to judge the extent to which milk can be relied upon as a source of vitamins for bottle-fed infants and very small children whose diet consists very largely, and sometimes wholly, of milk. Accordingly, the present study was undertaken to accumulate data concerning the amount and ratio of ascorbic, nicotinic, and pantothenic acids, riboflavin and thiamin in cow's milk.

## EXPERIMENTAL

The milk used in this study was produced by the college herd. Since the herd consisted of seventy cows of five different breeds, Ayrshire, Guernsey, Holstein, Jersey, and Shorthorn, individual breed characteristics and other factors, such as age, stage of lactation and pregnancy, were largely, if not completely, eliminated. The season selected for conducting the study was late summer when the pasture grasses were fully mature, but before severe frosts had affected their quality. Inasmuch as there was an urgent demand for maximum milk production, the pasture ration was supplemented with ground grains (14% protein) at the rate of one pound for each six pounds of milk that the cows produced. The cows were all normal healthy animals, and were maintained under continuous veterinary supervision.

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The cows were milked by machine at 3:30 P.M. and 3:30 A.M. The afternoon milk was cooled at once to 40° F. and stored at that temperature until the morning milk was cooled and added to it. A sample of the combined afternoon and morning milk was taken at 8:00 A.M. when the average age of the milk was about ten hours. The assays were commenced at once upon the raw milk.

## ASSAY PROCEDURES

The method described by Tripp, Satterfield and Holmes (26) and Holmes, Tripp, Woelffer, and Satterfield (8) was used to determine the ascorbic acid content of the milk. The nicotinic and pantothenic acids were assayed by Landy and Dicken (12) microbiological method using *Lactobacillus casei*. The milk samples were digested 24 hours at 45° C. with papain and clarase. The amounts of papain and of clarase used were 2 per cent of the weight of the sample. In computing the nicotinic and pantothenic acid content of the milk, allowance was made for the amounts of these vitamins in the enzymes. The riboflavin content of the milk was determined by the fluorescence method reported by Holmes, Jones, Wertz, and Kuzmeski (5). The thiochrome method of Hennessy and Cerecedo (3) was used in the assay of milk for its thiamin content.

## RESULTS

### *Ascorbic Acid*

The ascorbic acid in the fifteen samples of raw milk, table 1, varied from 17.1 to 20.3 mg. per liter and averaged $18.4 \pm 0.69$ mg. This value is slightly less than 19.7 mg. per liter obtained by Holmes, Jones, Wertz, and Kuzmeski (5), for winter milk produced about eight months earlier by the same herd of cows, but it is higher than 17.3 mg. per liter reported by Holmes, Tripp, Woelffer, and Satterfield (8) for raw certified milk.

### *Nicotinic Acid*

The nicotinic acid content of the milk varied from 0.96 mg. to 1.27 mg. per liter with an average of $1.1 \pm 0.10$ mg. per liter. This value is higher than the 0.66 mg. value reported by Williams, Cheldelin, and Mitchell (30) and 0.6–0.9 mg. values found by Noll and Jensen (20) for skimmilk. On the other hand it is lower than 1.46 mg. per liter reported by Bailey, Dann, and Satterfield (1) for Ayrshire milk produced in January, 3.0 mg. obtained by Kodicek (11) for fresh November and December milk, 1.2–4.4 mg. found by Melnick and Field (17), or 8.2 mg. per liter reported by Waisman and Elvehjem (27).

### *Pantothenic Acid*

The amount of pantothenic acid in the milk ranged from 3.35 mg. to 4.10 mg. per liter with an average of $3.66 \pm 0.31$ mg. per liter. The literature

consulted contained very little data concerning the pantothenic acid content of milk. Strong, Feeney, and Earle (25) found similar results, 4.0 mg. per liter, with those obtained in this study. Likewise, McElroy and Goss (16) obtained approximately the same value, *i.e.*, 4.5 mg. From their study, they concluded that pantothenic acid was synthesized by the microflora of the digestive tract for they limited the pantothenic acid intake of a cow to 17 mg. per day and obtained 41 mgs. daily in the milk that she produced. Jukes (10) reported that the whole milk he studied contained from 1.3 to 4.3 mg. with an average of 2.8 mg. of pantothenic acid per liter. Since milk forms the principal, if not the entire diet of infants, it is interesting to compare these values for the pantothenic acid content of milk with those reported for Royal Jelly which is an important food for the very young of another species. Pearson and Burgin (22) report that Royal Jelly contains 179 mg. of pantothenic acid per 1000 gm., which is about forty-five times as much as was found in the milk used in this study.

TABLE 1

*Vitamin content of late summer raw milk*

(Milligrams per liter)

| Sample No. | Ascorbic acid | Nicotinic acid | Pantothenic acid | Riboflavin | Thiamin |
|---|---|---|---|---|---|
| 1 | 18.5 | ..... | 3.45 | 1.48 | 0.53 |
| 2 | 17.3 | ..... | 3.95 | 1.29 | 0.45 |
| 3 | 18.3 | ..... | 3.88 | 1.39 | 0.53 |
| 4 | 18.0 | ..... | 3.55 | 1.31 | 0.43 |
| 5 | 17.5 | ..... | 4.10 | 1.44 | 0.41 |
| 6 | 17.1 | ..... | 4.05 | 1.43 | 0.44 |
| 7 | 17.9 | 1.27 | 3.35 | 1.40 | 0.43 |
| 8 | 17.8 | 1.00 | 3.37 | 1.32 | 0.41 |
| 9 | 18.8 | 1.01 | 3.85 | 1.34 | 0.42 |
| 10 | 18.8 | 1.05 | 3.47 | 1.31 | 0.45 |
| 11 | 18.3 | 0.96 | 3.27 | 1.32 | 0.41 |
| 12 | 20.3 | 1.14 | ..... | 1.38 | 0.43 |
| 13 | 18.8 | 1.13 | ..... | 1.31 | 0.44 |
| 14 | 18.8 | 1.14 | ..... | 1.42 | 0.45 |
| 15 | 19.3 | 1.20 | ..... | 1.42 | 0.44 |
| Average | $18.4 \pm 0.69$ | $1.1 \pm 0.10$ | $3.66 \pm 0.31$ | $1.37 \pm 0.08$ | $0.44 \pm 0.04$ |

### *Riboflavin*

The riboflavin content of the milk produced during the experiment varied from 1.29 mg. to 1.48 mg. per liter, and averaged $1.37 \pm 0.08$ mg. Except for these extreme values the variation was only 0.14 mg. which indicates the milk was of quite uniform riboflavin content. The average value is somewhat lower than 1.51 mg. reported by Holmes, Jones, Wertz, and Kuzmeski (5) and 1.45 mg. to 1.50 mg. reported by Holmes and Holmes (4) for raw winter milk produced by the same herd. It is also lower than the values, 1.76 to 2.55 mg. of riboflavin per liter, reported by Whitnah, Kunerth, and Kramer (28), 7.8 mg. reported by Lindholm (14), and 1.5 to 2.5 mg. reported

by Snell and Strong (24), but the riboflavin content of milk obtained in this study is higher than the values of 1.0 to 1.2 mg. per liter reported by Randoin and Raffy (23), and of 0.95 mg., reported by Williams, Cheldelin, and Mitchell (30).

*Thiamin*

The thiamin content of the samples of milk studied varied from a minimum of 0.41 mg. per liter to a maximum of 0.53 mg. per liter. The average value obtained for the 15 samples was $0.44 \pm 0.04$ per liter. This is identical with the value reported by Williams, Cheldelin, and Mitchell (30) for Jersey and Guernsey milk. A number of other investigators report somewhat lower results for the thiamin content of milk. Halliday and Deuel (2) found the average thiamin content of certified Holstein milk was 0.41 mg. per liter. Widenbauer and Heckler (29) obtained values ranging from 0.13 to 0.57 mg., and averaging 0.32 mg. per liter and Morgan and Haynes (18), found three samples of market milk contained 0.27, 0.30, and 0.32 mg. of thiamin per liter.

*Ratio of Vitamins in Milk*

Since cow's milk is a natural product that is extensively recommended and very generally used for human food, it is of interest to consider the ratio of vitamins in it. This is particularly the case for milk which is destined to be the principal and sometimes the whole source of nourishment for infants. The ratio of the five vitamins under consideration was computed for each of the fifteen samples of milk assayed, but since these data are rather voluminous, only the average values will be reported here. When the thiamin content of the milk was used as a basis of computation it was found that the ascorbic acid was 41.6, the pantothenic acid 8.2, the riboflavin 3.3, and the nicotinic acid 2.5 times larger. Using nicotinic acid as the basis of comparison, the ascorbic acid was 17.2, the pantothenic acid 3.3, the riboflavin 1.2, and the thiamin 0.39 times larger. Considering the riboflavin content of the milk as a basis, the ascorbic acid was 13.5, the pantothenic acid 2.7, the nicotinic acid 0.81, and the thiamin was 0.32 times as much. If pantothenic acid is used for comparison, the ascorbic acid was 4.2 times, riboflavin 0.28, nicotinic acid 0.26, and thiamin was 0.10 times the pantothenic acid content of the milk. Computed on the basis of the ascorbic acid in the milk, the amount of pantothenic acid was 0.21 times, the riboflavin 0.08, the nicotinic acid 0.06, and the thiamin was 0.02 times the amount of ascorbic acid found in the milk.

It is of interest to compare the ratio of the five vitamins in the milk under consideration, with the ratio of these vitamins recommended for infants. After extensive study by experts in the field of human nutrition, the Food and Nutrition Board of the National Research Council (19) adopted and recommended daily allowances of the various dietary essentials for

people of different ages. The recommended allowances for children under one year old are: ascorbic acid 30 mg., nicotinic acid 4 mg., riboflavin 0.6 mg., and thiamin 0.4 mg. daily, the ratio of the vitamins being ascorbic acid 75 times, nicotinic acid 10 times, and riboflavin 1.5 times that of thiamin. As stated above, the ascorbic acid content of the milk under investigation was 41.6 times, nicotinic acid was 2.5 times, and riboflavin was 3.3 times the thiamin content of the milk. Consequently, in order to modify this milk to meet the National Research Council's recommended dietary allowances for infant feeding, it is necessary to fortify it with natural or synthetic vitamins. The recommended allowance for ascorbic acid is 30 mg. daily, but the milk under investigation contained only 18.4 mg. per liter. Thus to obtain 30 mg. daily from the milk, an infant would have had to consume about one and two-thirds liters daily, a physical impossibility. Accordingly, it was a routine practice in infant feeding to supplement a modified cow's milk formula with orange, tomato, or other juices. Recently, however, because of the uncertain ascorbic acid content of oranges, as shown by Holmes, Pigott, and Tripp (7), Holmes, Patch, and Tripp (6), and others, hospitals and pediatricians have tended to supplement milk formulas with synthetic ascorbic acid since thereby a definite amount may be fed daily. One liter of the milk under discussion would supply exactly the amount of thiamin, twice as much riboflavin, but only one-fourth of the nicotinic acid recommended by the National Research Council for infants. Unfortunately, there are few natural foods suitable for infant feeding, which can be fed in sufficient amounts to provide the quantity of nicotinic acid required to fortify the milk under consideration to meet the vitamin allowances recommended by the National Research Council. Thus it appears that in order to modify the milk used in this study, which is doubtless typical of large volumes of commercial milk, so that it would meet the vitamin allowances recommended by the National Research Council for infant feeding, one must use foods exceedingly rich in nicotinic acid or a synthetic preparation of it.

## SUMMARY

Fifteen samples of late summer milk produced under typical modern dairy farm conditions, were assayed for ascorbic, nicotinic, and pantothenic acids, riboflavin, and thiamin. The average vitamin content of the milk was ascorbic acid $18.4 \pm 0.69$ mg., nicotinic acid $1.1 \pm 0.10$ mg., pantothenic acid $3.66 \pm 0.31$ mg., riboflavin $1.37 \pm 0.08$ mg., and thiamin $0.44 \pm 0.04$ mg. per liter. The ratio has been computed for each vitamin to the other four vitamins of the group. For instance, considered on the basis of the thiamin content of the milk, the ascorbic acid is 41.6 times, nicotinic 2.5, and riboflavin 3.3 times its thiamin content, whereas the recommended vitamin allowances for infants are in the ratio of ascorbic acid 75 times, nicotinic acid 10 times, and riboflavin 1.5 times that of thiamin. Hence the milk

under consideration would have to be fortified with ascorbic and nicotinic acids to meet the recommended allowances for infant feeding.

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# A NOTE REGARDING THE SPEEDS OF BABCOCK CENTRIFUGES

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When Stephen M. Babcock first described his test for fat in milk (1), he did not specify the exact speed at which bottles were to be centrifuged. In a later report (2), he said that the speed should vary between 700 and 1200 r.p.m. depending upon the diameter of the wheel, but he did not go into details.

Several years later, a table was published by others (3) which was supposed to show the speeds at which machines of various sizes should be operated to secure equal centrifugal forces. During the past forty-seven years, this table has been incorporated into most textbooks dealing with the subject, and into the Babcock regulations of many of the states, in spite of the fact that it is based upon a faulty assumption.

The faults of the present table become obvious when one considers the statement that a machine 10 inches in diameter (5-inch radius) is to be operated at a speed of 1074 r.p.m. As a standard test bottle is 6.5 inches high, the neck of the bottle would project 1.5 inches past the center of the machine, and any fat in this portion of the neck would actually be thrown out of the bottle by centrifugal force. Nevertheless, the regulations of at least seven states apparently authorize this procedure.

It should be stated that the authors of this table were undoubtedly aware of this situation. Their values for centrifuges of small radius are appropriate if very short bottles are centrifuged, such as those less than five inches high which are sometimes used for testing human milk. These criticisms are directed, not toward the table itself, but toward its misuse by the unwary who may not realize that the proper radius of the machine, and its proper speed, are dependent upon the height of the bottle which is to be centrifuged.

The table of speeds in common use was calculated to yield equivalent forces upon particles in the bottoms of the cups. The forces acting upon the material inside the bottle, or in the neck, are substantially less because they are nearer the center of rotation. Table 1 shows the relative forces acting at the bottom of the cup, at the fat-acid interface during the first (and principal) centrifuge period and at a point half way up the neck of the bottle, under the conditions which are commonly specified.

Obviously this table gives equal forces at the wrong place in the test bottle. However, it is not obvious which point in the test bottle should be used for these calculations.

It seems probable that the first centrifuging is the most critical of the three centrifuge periods. During the first period, the centrifugal force must

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TABLE 1

*Relative forces at different positions in the bottle when centrifuged at the speeds in common use*

| Diameter | Speed | Relative forces exerted | | | |
|---|---|---|---|---|---|
| | | At the bottom | 1.5 inches above the bottom | At the middle of the neck | |
| | | | | 6-inch bottle | 9-inch bottle |
| | *r.p.m.* | | | | |
| 10 | 1074 | 1 | 0.7 | 0.050 | −0.200 |
| 12 | 980 | 1 | 0.75 | 0.208 | 0.000 |
| 14 | 909 | 1 | 0.786 | 0.321 | 0.143 |
| 16 | 848 | 1 | 0.813 | 0.406 | 0.250 |
| 18 | 800 | 1 | 0.833 | 0.472 | 0.333 |
| 20 | 759 | 1 | 0.850 | 0.525 | 0.400 |
| 22 | 724 | 1 | 0.866 | 0.568 | 0.455 |
| 24 | 693 | 1 | 0.875 | 0.604 | 0.500 |

act upon fat in the form of minute droplets and collect it into an oily layer. During the later periods, this oil layer is brought into the neck of the bottle, and much smaller forces are needed because of the larger sizes of the oil droplets. If this first centrifuging is the most important one, it would seem advisable to standardize the force acting at the top of the acid layer at that time. The forces acting below this surface would always be greater than the standard force, never smaller.

For this reason, it is suggested that speeds should be used which yield equal forces at a point 1.5 inches above the bottom of the centrifuge cups. These speeds are given in table 2. This table also shows the relative forces acting in each case at the bottom of the cup, and at a point half way up the neck.

TABLE 2

*Relative forces at different points in the test bottle when centrifuged at the proposed new speeds*

| Diameter | Speed | Relative forces exerted | | | |
|---|---|---|---|---|---|
| | | At the bottom | 1.5 inches above the bottom | At the middle of the neck | |
| | | | | 6-inch bottle | 9-inch bottle |
| | *r.p.m.* * | | | | |
| 10 | 1171 | 1.428 | 1 | 0.071 | −0.286 |
| 12 | 1033 | 1.333 | 1 | 0.278 | 0.000 |
| 14 | 934 | 1.272 | 1 | 0.409 | 0.182 |
| 16 | 859 | 1.230 | 1 | 0.500 | 0.308 |
| 18 | 800* | 1.200 | 1 | 0.567 | 0.400 |
| 20 | 751 | 1.176 | 1 | 0.617 | 0.471 |
| 22 | 711 | 1.157 | 1 | 0.657 | 0.526 |
| 24 | 677 | 1.142 | 1 | 0.690 | 0.576 |

* According to Farrington and Woll (3), Babcock's machine was 18 inches in diameter. Their table of speeds was calculated with the assumption that such a machine should operate at 800 r.p.m. This assumption was retained when calculating the speeds in this table.

It is apparent that the force in the neck of the bottle may be relatively low, especially in the machines of smaller diameter. It would seem undesirable to have this force become too small because of the slow separation of water emulsified in the fat column. There are no data available to indicate the minimum permissible force in the neck of the test bottle. However, the use of ten-inch and twelve-inch machines should certainly be discouraged; in fact, they have already been dropped in some states, and it might be advisable to discontinue the use of fourteen-inch machines, at least in the case of commercial and official testing. When the long-neck cream bottles are used, the use of even an eighteen-inch tester would appear questionable.

## SUMMARY

The table of speeds of Babcock centrifuges in common use gives equal forces at the bottom of the cup, not in the bottle where the sample is placed. A new table has been calculated to produce equal forces at the fat-acid interface during the first centrifuging period. It is recommended that the use of small diameter centrifuges be discontinued because the force acting to remove water emulsified in the fat column is very small in the small machines.

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# THE VALUE OF KELP MEAL IN RATIONS FOR DAIRY CATTLE[1]

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Dried kelp has found considerable use as a source of minerals in livestock feeding. According to the producers of kelp meal, it contains a remarkably high content of some 30 odd mineral salts that are beneficial to the health of livestock, especially with respect to their reproductive functions, growth, and increased milk production. On the other hand, a limited number of available reports on the use of kelp meal, or kelp in combination with other products in proprietary mixtures, have shown no appreciable benefits from adding them to well balanced rations for dairy heifers and dairy cows (1, 2, 3, 4, 6).

Because of the claims made and the fact that many dairymen have purchased kelp meal, or mixtures containing kelp, it seemed practicable to conduct an investigation to obtain more information on the value of adding kelp meal to the rations of dairy cattle, and the results are herein reported. The kelp meal used was produced from the giant kelp (*Marcocystis pyrifera*) that grows in the Pacific Ocean off the coast of Southern California.

An average analysis of the meal made from the dried ground plant is as follows:

| | |
|---|---|
| Ash (natural plant minerals) | 35.2% |
| Carbohydrates (nitrogen-free extract) | 42.9 |
| Protein | 5.6 |
| Fat (ether-soluble) | 0.5 |
| Fiber | 6.5 |
| Moisture | 9.3 |
| | 100.0% |

## EXPERIMENTAL

The original plan was to feed a group of heifers from an average age of 12 months to first calving on the usual roughages and a grain mixture containing 4 per cent kelp meal and to compare the results obtained with another group fed the same grain mixture without the kelp. During the progress of the investigation, however, the plan was modified to continue the animals through their second gestation period to obtain data for a second parturition. Also, this provided an opportunity to obtain lactation data.

Seventy-eight heifers (24 Holsteins, 24 Ayrshires, 18 Guernseys, and 12 Jerseys) were started on the experiment and 50 of these animals (18

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Holsteins, 18 Ayrshires, 8 Guernseys and 6 Jerseys) were continued through the second gestation period. When placed on the experiment, the heifers were paired according to breed, age, size and previous growth data. For the most part, the heifers of each pair were paternal half-sisters. They were free of known diseases and were examined for any genital abnormalities before breeding. All heifers were bred to freshen at 27 to 30 months of age.

The heifers received U. S. No. 2 clover hay and corn silage in amounts that would be readily consumed each day. They received no pasture. In addition, four pounds of a concentrate mixture containing approximately 14 per cent total protein were fed to each heifer daily. The grain mixture was as follows:

600 lbs. yellow corn meal
600 lbs. ground oats
500 lbs. wheat bran
250 lbs. linseed meal
30 lbs. steamed bonemeal
20 lbs. salt

Heifers on the kelp ration received the same mixture to which was added four per cent kelp meal. The amount of concentrates fed was increased before calving, depending upon the physical condition of the individual heifer. About two weeks before calving a mixture of ground oats and wheat bran was substituted for the regular concentrate mixture. Four per cent of kelp meal was added to the oats and bran for the animals in that group.

During lactation, a grain mixture containing 16 to 18 per cent total protein was fed. This mixture contained one per cent each of bonemeal and salt. Four per cent of kelp meal was added to this mixture for the kelp-fed cows. The amount of grain fed to each cow was adjusted weekly on the basis of production during the preceding week. Grain was fed at the rate of 1 pound to each 3½ pounds of milk produced for Ayrshires and Holsteins and 1 pound to each 3 pounds of milk produced for Guernseys and Jerseys. Roughages consisted of U. S. No. 2 leafy alfalfa hay and corn silage. The cows were fed all they would consume readily of these roughages when fed twice daily. No pasture was available. All feeds were weighed and refused feed was accounted for in order to determine whether kelp meal had any effect on feed consumption.

## RESULTS

*Reproduction.* Growth and reproductive data are presented in table 1 for all heifers through the first gestation period.

As noted in table 1, gains in liveweight for both groups of heifers were practically equal, showing no advantage to either ration in this respect. Likewise, no favorable effect of kelp meal is shown in breeding efficiency. In the control group, 1.46 services were required for each conception, while

1.86 services per conception were required by the heifers receiving kelp. Sixty-five per cent of the control heifers conceived on the first service as compared with 54 per cent for the kelp animals.

There were two abortions in each group, five cases of retained placenta in the control group and two in the kelp group, and two heifers from each group were discarded as non-breeders. All of these non-breeders showed genital abnormalities which could not be attributed to the rations being fed. If an animal failed to carry her calf 260 days it was considered as an abortion.

Eliminating the animals which aborted, there were no differences in length of gestation between the two groups. No significant differences were

TABLE 1

*Growth and breeding data on heifers through first gestation*

| | Control ration | Kelp ration |
|---|---|---|
| Number of animals | 39 | 39 |
| Average daily gain (lbs.) | 1.05* | 1.03* |
| Services per conception | 1.46* | 1.86* |
| Service at which conception occurred: | | |
| First (%) | 65 | 54 |
| Second (%) | 30 | 22 |
| Third or more (%) | 5 | 24 |
| Length of gestation (days) | 276.5† | 275.9† |
| Abortions | 2 | 2 |
| Retained placentas | 5 | 2 |
| Non-breeders | 2 | 2 |
| Av. deviation in wt. of calves at birth from normal (lbs.) | −3.34 | −1.09 |
| Physical condition of calves at birth | 29 Good | 30 Good |
| | 4 Fair | 5 Fair |
| | 0 Thin | 0 Thin |
| | 2 Poor | 0 Poor |

* Does not include 2 animals from each group discarded as non-breeders.

† Does not include 2 animals from each group that aborted and 1 animal from control group for which date of service was not recorded.

noted in the condition of calves at birth, except that two small, weak calves were born in the control group. The average birth weights of the calves slightly favored the kelp-fed group. The normal birth weights used for comparison were those of Morrison (5). Weights below normal were to be expected since they were all from first calf heifers.

While the data on services required for conception tend to favor the control group, the number of abortions was the same in both groups and the physical condition of the calves at birth gives a small advantage to the kelp-fed group. Such differences are not great enough to be significant.

After part of the heifers had calved and were taken off the experiment, it was decided to continue the remaining animals on through their second gestation. This allowed the feeding of kelp through two consecutive gestation periods and makes it possible to study the effect of continuous feeding

of kelp meal. Such data are available on 25 pairs of animals and a comparison of the results for the first and second calvings is given in table 2.

When the results of the second gestation and calving period are compared with those of the first, no improvement is observed in breeding efficiency of the kelp-fed animals. Services per conception remained about equal for the second gestation as compared with the first and the physical condition of the calves at birth was essentially the same. The size of calves at birth was slightly lower on the kelp ration than on the control ration at second calving. At first calving, the reverse was true.

TABLE 2

*Comparison of breeding records between first and second gestations*

| | Control ration | | Kelp ration | |
|---|---|---|---|---|
| | First gestation | Second gestation | First gestation | Second gestation |
| Number of animals | 25 | 25 | 25 | 25 |
| Services per conception | 1.56 | 2.20 | 1.92 | 1.96 |
| Service at which conception occurred: | | | | |
| First (%) | 60 | 52 | 56 | 44 |
| Second (%) | 32 | 8 | 20 | 28 |
| Third or more (%) | 8 | 40 | 24 | 28 |
| Length of gestation (days) | 276.9 | 278.8* | 275.3 | 277.7* |
| Abortions | 0 | 4 | 0 | 3 |
| Retained placentas | 1 | 2 | 1 | 4 |
| Non-breeders | 0 | 0 | 0 | 0 |
| Av. deviation in wt. of calves at birth from normal (lbs.) | −1.08 | +5.68† | 0 | +4.86 |
| Physical condition of calves at birth | 24 Good | 21 Good | 21 Good | 20 Good |
| | 0 Fair | 0 Fair | 4 Fair | 2 Fair |
| | 0 Thin | 0 Thin | 0 Thin | 0 Thin |
| | 1 Poor | 0 Poor | 0 Poor | 0 Poor |

* Does not include 4 animals in control group and 3 animals in kelp group that aborted.

† Includes a pair of twins in control group.

The number of cases of retained placenta increased for the second calving as compared with the first calving for the kelp-fed animals. Also, there was a higher number of abortions in both groups. It is highly questionable if these abortions should be attributed to the experimental rations. The University herd has been free from Bang's disease, trichomoniasis and other genital infections, but an unusually large number of abortions occurred in the entire herd during the progress of this investigation. Apparently these abortions have been due to some other cause as yet undiscovered. It is worthy of note, however, that whatever the cause may be it was not improved by the addition of kelp meal to the ration.

*Milk production.* Lactation and feed records were kept for the first 305 days, except in a limited number of cases where the animals went dry before

milking that long. After the cows were dried off they were changed to the concentrate mixtures fed the heifers.

Feed consumption and lactation data are presented in table 3.

These records show no consistent differences which can be attributed to the rations fed. While a slightly higher production was obtained from the cows on the control ration, when the variability is considered, this difference is not significant and probably can be accounted for on the basis of individuality of the animals.

The addition of kelp meal had no stimulating effect upon appetite since feed consumption was essentially the same on both rations. The feed required to produce 100 pounds of four per cent milk was almost identical for the two rations.

TABLE 3

*Average milk production and feed consumption during lactation*

| | Control ration | Kelp ration |
|---|---|---|
| Number of animals | 25 | 25 |
| Av. age at freshening (yrs.) | 2.47 | 2.51 |
| Changes in liveweight (lbs.) | +44.9 | +78.4 |
| Length of lactation (days) | 303.5 | 303.4 |
| Milk production (lbs.) | 8076.2 | 7537.6 |
| Fat percentage | 4.01 | 4.14 |
| Fat (lbs.) | 323.8 | 312.2 |
| 4% fat-corrected milk (lbs.) | 8086.9 | 7698.2 |
| Grain consumption (lbs.) | 2487.6 | 2338.4 |
| Silage consumption (lbs.) | 9116.3 | 9170.3 |
| Hay consumption (lbs.) | 2887.2 | 2785.4 |
| Grain per cwt. 4% F. C. M. (lbs.) | 30.8 | 30.4 |
| Silage per cwt. 4% F. C. M. (lbs.) | 112.7 | 119.1 |
| Hay per cwt. 4% F. C. M. (lbs.) | 35.7 | 36.2 |

Growth during lactation, as measured by changes in liveweight, slightly favors the kelp ration, but the difference is not significant.

At no time during the progress of this investigation was it possible to detect any consistent differences in physical appearance of the animals on the two rations. Both groups maintained a good, thrifty condition.

## DISCUSSION

These results do not show any special health or growth benefits from the addition of four per cent kelp meal to the grain mixtures of dairy heifers and cows. The normal ration contained steamed bonemeal as a source of calcium and phosphorus. It is possible, of course, that if the control ration had been very low in mineral content, *i.e.*, deficient in phosphorus, calcium or iodine, the results might have been more favorable to kelp meal. The primary objective, however, was to determine if the trace or rare minerals con-

tained in kelp would show any benefits after feeding for an extended period of time over those obtained from feeding rations generally considered satisfactory and containing the simple supplements, salt and bonemeal.

In some cases, claims have been made that beneficial results from kelp were not obtained because it was fed for an insufficient length of time. Because of this the experiment was continued through the second gestation and it would seem that 30 months of continuous feeding of kelp meal at the rate of four per cent in the grain mixture is sufficient for any effects to show up. It is appreciated that kelp and other marine products furnish iodine, and in sections where a deficiency of iodine manifests itself, the results might have been slightly different. Also, it is known that the iodine content of milk may be increased by feeding products rich in the mineral element. However, the results of this investigation confirm those previously reported in showing no benefits from adding kelp to well balanced rations for dairy heifers with respect to growth, breeding efficiency, and milk production.

## SUMMARY

Feeding experiments have been completed with 39 pairs of heifers to determine the value of adding kelp meal to dairy rations. Kelp meal was fed at the rate of four per cent of the concentrate mixture to one animal of each pair.

Under the conditions of this investigation, the addition of kelp meal to normal rations for dairy heifers showed no particular benefits for growth, breeding efficiency, general health, physical condition, appetite, and size and condition of calves at birth.

Continued feeding of kelp meal through a second gestation showed no favorable effects on breeding efficiency, feed consumption, and milk production.

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# EFFECT OF COLOSTRUM ON THE VITAMIN A AND CAROTENE CONTENT OF BLOOD PLASMA OF NEW-BORN CALVES*

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The literature on colostrum from the standpoint of the protection it affords the young by immunization against certain types of infections has been amply reviewed by Rogers and associates (8). Colostrum, however, contains vitamins and possibly many other substances which are necessary for the proper health of the new-born. Dann (1) found the vitamin A concentration in colostrum may be 10 to 100 times greater than in later milk from the same cow. He states "on the first day of life a calf receives supplies of vitamin A greater than the later milk could give in 20 to 50 days." Stewart and McCallum (12) found the vitamin A content of colostrum varied from 35 to 1181 I.U. per 100 ml. in samples collected from 100 cows. By the third or fourth day the amount of vitamin A is 1/10 to 1/20 that taken immediately after parturition. Semb and associates (9) found the carotene and vitamin A content of butterfat prepared from colostrum was from 5 to 15 times that of fat from ordinary milk. They emphasized the importance of colostrum to build up the vitamin A stores in new-born calves. Kramer and co-workers (3) reported values of 25 and 28 International Units of vitamin A activity per gram of colostrum for two cows receiving rye pasture and values of 16 and 20 International Units for two cows on winter rations.

Stewart and McCallum (14) were unable to increase the vitamin A content of colostrum by feeding 3 lbs. of carrots or 1/7 pint of codliver oil per day to cows on winter feed. These same authors (13) also made an extensive study of the correlation between the incidence of white scours in calves and the vitamin A content of the colostrum. In 83 calves which received colostrum containing more than 250 blue units of vitamin A, 10.8 per cent developed white scours or allied infections; whereas, in 28 calves which received colostrum containing less than 250 blue units of vitamin A, 25 per cent developed white scours or allied infections.

The effect of the intake of colostrum on the vitamin A and carotene content of the blood plasma of calves has not been widely studied. Phillips, Lundquist, and Boyer (7) have reported data on a few calves. Lundquist and Phillips (4) reported data on 45 calves on blood samples drawn at birth, the first, second and seventh days.

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Because of the practical importance of colostrum to the new-born and because all the factors concerned have not been evaluated, it was decided to study the effect of colostrum intake on the vitamin A and carotene content of blood plasma of new-born calves. The results of the study are reported herein.

## EXPERIMENTAL

Blood samples were drawn from calves dropped in the University of Maryland herd of the Holstein, Ayrshire, Jersey and Guernsey breeds before sucking and for each day thereafter for one week. Plasma vitamin A and carotene determinations were made according to a previously published procedure (5) modified as suggested by Kimble (2). The calves were left with the cow for 3 days and thereafter received whole milk at the rate of about one pound for each 10 pounds of live weight.

Colostrum was withheld from 3 calves in order to study the effect on the vitamin A and carotene content of the blood plasma. Whole milk was fed in place of the colostrum. Three calves were permitted to receive colostrum for only 12 hours and three for 24 hours.

## RESULTS AND DISCUSSION

The main results have been summarized in table 1 along with the standard error for each set of averages. The results show that the blood plasma of a new-born calf is low in vitamin A and carotene. A calf with similar low values at 3 to 12 months of age would show a marked deficiency and would not be able to survive. This might indicate a considerably greater requirement for vitamin A after birth than while being carried in utero. It could be argued that the calf carried in utero has no vitamin A requirement. This line of reasoning, however, is not valid because the same pathology is produced in utero if the dam is fed a deficient ration as is produced in vitamin A deficiency in a growing calf after birth.

After 24 hours the vitamin A content of the plasma increases four to five fold as would be expected because of the high vitamin A content of the colostrum. A maximum is usually reached at the third to fourth day after which there is a gradual decline. The decline is due to the fact that the calves are removed from the cow on the third day and fed whole milk which is lower in vitamin A. It seems likely, however, that the same decline would be noted even though the calves were left on the cow since by this time the secretion from the udder assumes the characteristics of whole milk. These data are in agreement with those reported by Lundquist and Phillips (4) in respect to the effect of colostrum on the vitamin A content of the blood plasma of new-born calves.

The data also show no particular breed variations in the vitamin A content of the blood plasma on comparable days. This would indicate that the

TABLE 1

*Effect of colostrum on blood plasma vitamin A and carotene of calves for the first week*

| Age in days | Holstein | | Ayrshire | | Jersey | | Guernsey | |
|---|---|---|---|---|---|---|---|---|
| | No. of animals | μg per 100 ml. | No. of animals | μg per 100 ml. | No. of animals | μg per 100 ml. | No. of animals | μg per 100 ml. |
| | | | | Vitamin A | | | | |
| 0 (birth) | 17 | 3.3 ± 0.48 | 12 | 3.6 ± 0.57 | 5 | 2.4 ± 0.45 | 8 | 4.2 ± 0.84 |
| 1 | 17 | 15.6 ± 1.80 | 15 | 13.2 ± 1.32 | 7 | 14.1 ± 2.07 | 12 | 16.5 ± 1.38 |
| 2 | 16 | 16.8 ± 1.34 | 15 | 17.1 ± 1.14 | 7 | 20.1 ± 2.43 | 12 | 16.4 ± 1.64 |
| 3 | 17 | 15.9 ± 1.32 | 14 | 18.3 ± 0.93 | 7 | 17.4 ± 2.10 | 12 | 15.6 ± 1.32 |
| 4 | 16 | 15.0 ± 1.44 | 12 | 15.0 ± 0.78 | 6 | 15.9 ± 1.44 | 13 | 14.1 ± 1.29 |
| 5 | 15 | 14.4 ± 1.47 | 11 | 16.2 ± 1.59 | 5 | 14.1 ± 1.05 | 11 | 15.0 ± 0.96 |
| 6 | 16 | 13.2 ± 1.26 | 10 | 14.7 ± 1.38 | 5 | 9.9 ± 1.11 | 9 | 15.0 ± 0.48 |
| 7 | 13 | 13.8 ± 0.84 | 9 | 15.3 ± 1.02 | 6 | 11.4 ± 0.84 | 8 | 15.9 ± 1.56 |
| | | | | Carotene | | | | |
| 0 (birth) | 17 | 1.8 ± 0.11 | 12 | 1.5 ± 0.06 | 5 | 3.4 ± 0.49 | 8 | 2.9 ± 0.49 |
| 1 | 17 | 14.9 ± 0.64 | 15 | 18.1 ± 0.59 | 7 | 30.1 ± 2.30 | 12 | 39.1 ± 1.33 |
| 2 | 16 | 17.4 ± 0.63 | 15 | 23.7 ± 0.85 | 7 | 48.7 ± 3.71 | 12 | 52.9 ± 1.45 |
| 3 | 17 | 18.8 ± 0.59 | 14 | 28.1 ± 0.86 | 7 | 49.9 ± 3.75 | 12 | 57.7 ± 1.91 |
| 4 | 16 | 19.1 ± 0.77 | 12 | 27.8 ± 0.90 | 6 | 57.3 ± 3.16 | 13 | 55.9 ± 1.84 |
| 5 | 15 | 18.7 ± 0.56 | 11 | 26.4 ± 1.01 | 5 | 47.6 ± 3.62 | 11 | 52.2 ± 2.04 |
| 6 | 16 | 17.4 ± 0.44 | 11 | 24.5 ± 0.83 | 5 | 45.6 ± 3.10 | 10 | 50.4 ± 1.90 |
| 7 | 13 | 16.5 ± 0.41 | 9 | 23.1 ± 1.07 | 6 | 41.2 ± 2.98 | 8 | 53.0 ± 1.55 |

supposedly greater difficulty of raising Jersey and Guernsey calves does not lie in the vitamin A metabolism during the first week of life.

The carotene content of the blood plasma of calves shows somewhat the same trend of increase as the vitamin A except here there are marked breed differences. The carotene is much higher for the Jersey and Guernsey breeds than for the Holstein and Ayrshire breeds. In this connection an Ayrshire calf 12 hours of age was placed on a Guernsey cow which had just freshened. The carotene values of the blood plasma of the Ayrshire calf on the Guernsey cow then assumed the high values noted for the Guernsey calves. This would indicate that the breed differences in the carotene content of the blood plasma of calves of this age was due to the carotene content of the colostrum of the breed and possibly not to differences in carotene metabolism in the calf as is true a little later in the growth period (6).

TABLE 2

*Vitamin A and carotene content of blood plasma of calves which did not respond to colostrum*

| Age, days | Guernsey female* | | Ayrshire female† | | Holstein female‡ | |
|---|---|---|---|---|---|---|
| | Vitamin A | Carotene | Vitamin A | Carotene | Vitamin A | Carotene |
| | *micrograms per 100 ml.* | | | | | |
| 0 | 3.3 | 4.0 | 2.7 | 1.0 | 1.2 | 2.0 |
| 1 | 3.3 | 6.0 | 2.1 | 1.0 | 2.1 | 2.0 |
| 2 | 3.3 | 5.0 | 2.7 | 1.0 | ..... | ..... |
| 3 | 3.3 | 5.0 | 0.6 | 1.0 | ..... | ..... |
| 4 | 2.1 | 4.0 | ..... | ..... | ..... | ..... |
| 5 | 1.2 | 2.0 | ..... | ..... | ..... | ..... |
| 6 | 2.1 | 4.0 | ..... | ..... | ..... | ..... |
| 7 | 2.1 | 4.0 | ..... | ..... | ..... | ..... |

* Died at 13 days of age.
† Died at 4 days of age.
‡ Died at 2 days of age.

It should be noted here that there were marked differences between calves of the same breed. These differences are probably related to the extreme variations previously noted in the vitamin A content of colostrum (1, 9, 12). These variations in colostrum might be of considerable practical importance since calves receiving colostrum of a low vitamin A value would not be able to build up their vitamin A reserve. Stewart and McCallum (12) noted that the longer the dry period the higher the vitamin A content of the colostrum. In three extreme cases the vitamin A and carotene values increased but little above the original values as shown in table 2. All of these calves died. Whether these observations were due to colostrum of poor quality or to an infection of the digestive tract which prevented absorption of vitamin A was not determined. It is possible that where the colostrum is low in vitamin A it might also be low in its content of immunizing bodies which the new-born calf needs in its defense mechanism against certain bacteria. This point would seem worthy of investigation.

TABLE 3

*Effect on blood plasma vitamin A and carotene of withholding colostrum*

| Age, days | Holstein male | | Holstein male* | | Guernsey male† | |
|---|---|---|---|---|---|---|
| | Vitamin A | Carotene | Vitamin A | Carotene | Vitamin A | Carotene |
| | *micrograms per 100 ml.* | | | | | |
| 0 | 2.7 | 2.0 | 0.6 | 1.0 | 3.6 | 4.0 |
| 1 | 3.0 | 3.0 | 1.8 | 1.0 | 3.9 | 4.0 |
| 2 | 3.3 | 4.0 | 1.5 | 3.0 | ..... | ..... |
| 3 | 3.9 | 6.0 | 3.9 | 5.0 | ..... | ..... |
| 4 | 6.0 | 8.0 | 1.8 | 4.0 | ..... | ..... |
| 5 | 4.6 | 6.0 | 1.2 | 9.0 | ..... | ..... |
| 6 | 4.5 | 8.0 | 3.0 | 7.0 | ..... | ..... |
| 7 | 6.9 | 10.0 | 2.7 | 9.0 | ..... | ..... |

* Died 10 days of age.
† Sick at 2 days of age. Died at 3 days of age.

When three calves were not permitted to take colostrum but were fed whole milk instead, the blood plasma vitamin A and carotene values remained at a low level as shown in table 3. Two of these calves died, one at three days of age and one at ten days of age. This checks the observations of Smith and Little (10) who found that calves receive certain immune bodies from the colostrum to protect them against certain types of infection. One might be led to the conclusion that vitamin A also played some role in this regard since the vitamin A content of the blood plasma remains at a low level as shown in table 3. However, Smith and Little (11) also showed that the injection and ingestion of 200 to 300 ml. of cow serum prevented these early deaths when colostrum was withheld. It does not seem likely that the intake of this amount of serum would have any great effect on the level of blood plasma vitamin A or carotene. In studies with new-born calves the possible effect of these immunizing bodies on the health of the calf should not be overlooked in the interpretation of data related to nutrition.

The limited results from tables 4 and 5 indicate that the calf does not usually receive the full benefit from the colostrum in so far as vitamin A

TABLE 4

*Effect on blood plasma vitamin A and carotene of removing calf from cow after 12 hours*

| Age, days | Guernsey male | | Holstein male | | Guernsey male | |
|---|---|---|---|---|---|---|
| | Vitamin A | Carotene | Vitamin A | Carotene | Vitamin A | Carotene |
| | *micrograms per 100 ml.* | | | | | |
| 0 | 2.7 | 9.0 | 1.5 | 2.0 | 2.4 | 8.0 |
| 1 | 8.1 | 27.0 | 10.5 | 16.0 | 12.0 | 68.0 |
| 2 | 7.8 | 26.0 | 12.0 | 21.0 | 13.5 | 79.0 |
| 3 | 5.7 | 19.0 | 9.9 | 25.0 | 7.2 | 78.0 |
| 4 | 7.8 | 26.0 | 9.9 | 23.0 | 9.0 | 82.0 |
| 5 | 3.3 | 11.0 | 9.0 | 23.0 | 9.3 | 76.0 |
| 6 | 6.6 | 22.0 | 8.7 | 23.0 | 6.9 | 72.0 |
| 7 | 6.6 | 23.0 | 9.6 | 23.0 | 4.7 | 69.0 |

is concerned when removed from the dam at 12- and 24-hour periods after birth as indicated by the vitamin A values of the blood plasma when compared to the averages presented in table 1. The best practice would be to leave the calf with its dam for at least 3 days so as to take full advantage of the high vitamin A content of the colostrum unless of course the colostrum is hand-fed.

The intake of colostrum probably gives the new-born calf a chance to build up a considerable reserve of vitamin A in the liver. If the calf does not receive the colostrum, that reserve is not built up and may have considerable to do with the health of the calf during the first few months of life before hay is consumed to any great extent.

TABLE 5

*Effect on blood plasma vitamin A and carotene of removing calf from cow after 24 hours*

| Age, days | Holstein male | | Guernsey male | | Holstein male | |
|---|---|---|---|---|---|---|
| | Vitamin A | Carotene | Vitamin A | Carotene | Vitamin A | Carotene |
| | *micrograms per 100 ml.* | | | | | |
| 0 | 3.6 | 2.0 | 2.1 | 4.0 | ..... | 1.0 |
| 1 | 19.5 | 18.0 | 6.8 | 23.0 | 13.5 | 3.0 |
| 2 | 22.5 | 22.0 | 7.5 | 43.0 | 10.8 | 6.0 |
| 3 | 15.0 | 22.0 | ..... | ..... | 12.0 | 10.0 |
| 4 | 9.5 | 19.0 | 6.6 | 37.0 | 9.3 | 14.0 |
| 5 | 13.5 | 15.0 | 7.0 | 39.0 | 10.5 | 10.0 |
| 6 | 15.9 | 15.0 | 7.5 | 38.0 | 7.2 | 8.0 |
| 7 | 7.7 | 15.0 | 9.9 | 38.0 | 12.0 | 9.0 |

The colostrum milk on most dairy farms is discarded since it cannot be included in milk sold for market purposes. This would appear to be most wasteful of a large amount of vitamin A and many other factors necessary for the health of calves. Studies should be made to determine whether this milk could be mixed with the whole milk fed with some possible benefit to the calves being raised in the herd.

## SUMMARY

1. The vitamin A content of the blood plasma of dairy calves at birth was low but at the end of 24 hours usually showed about a 5-fold increase with the intake of colostrum.

2. Maximal vitamin A and carotene values were attained at about three days of age after which there was a gradual decline.

3. There was no marked difference between breeds in the vitamin A content of the blood plasma at comparable ages; however, the carotene content of the blood plasma of the Jersey and Guernsey breeds was three to four times higher than for the Holstein breed.

4. In three cases neither the plasma vitamin A nor carotene values showed an increase even though the calves apparently consumed the colostrum. These calves died from infection.

5. In three cases where the colostrum was withheld and whole milk was fed, the plasma vitamin A and carotene content showed very little increase. Two of these calves died of infection.

6. The plasma vitamin A and carotene values did not reach the maximum values where the calves were removed at 12 and 24 hours after birth.

7. The intake of colostrum probably gives the calf a chance to build up a considerable reserve of vitamin A in the liver. If the calf does not receive the colostrum, that reserve is not built up and may have considerable to do with the health of the calf during the first two months.

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# THE EFFECT OF STORAGE ON THE RETENTION OF CERTAIN MEMBERS OF THE VITAMIN B COMPLEX*

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Considerable work has been done on the stability of carotene under storage on such plant products as alfalfa, clover, timothy hays, alfalfa leaf meal, etc. With the ever-increasing knowledge of the role of the B complex

TABLE 1

*Thiamine*

| No. | Material | New material, fall—1942 | One year storage, ground | One year storage, unground |
|---|---|---|---|---|
| | | *milligrams per 100 grams* | | |
| 1 | Alfalfa hay | 0.23 | 0.23 | 0.23 |
| 2 | Timothy hay | 0.17 | 0.19 | 0.17 |
| 3 | Clover hay | 0.14 | 0.19 | 0.18 |
| 4 | Alfalfa leaf meal | 0.26 | 0.21 | 0.13 |
| 5 | Cerophyll | 0.31 | 0.41 | 0.38 |
| 6 | Peas | 0.23 | 0.23 | 0.23 |
| 7 | Pea pods | 0.24 | 0.24 | 0.25 |
| 8 | Soybeans | 1.55 | 1.56 | 1.47 |
| 9 | Yellow corn | 0.59 | 0.54 | 0.55 |
| 10 | White corn | 0.43 | 0.45 | 0.42 |
| 11 | Navy beans | 0.47 | 0.54 | 0.54 |
| 12 | Oats—Vicland | 0.57 | 0.47 | 0.46 |
| 13 | Oats—Ped. No. 7 | 0.43 | 0.77 | 0.42 |
| 14 | Oats—X219–1* | 0.38 | 0.39 | 0.38 |
| 15 | Oats—CI 3662 | 0.26 | 0.26 | 0.26 |
| 16 | Oats—Erban | 0.38 | 0.39 | 0.36 |
| 17 | Barley—Ped. 38 | 0.61 | 0.44 | 0.48 |
| 18 | Barley—Ped. 5–1 | 0.56 | 0.59 | 0.53 |
| 19 | Barley—X191–2–1–2 | 0.62 | 0.66 | 0.65 |
| 20 | Rye—Imperial | 0.19 | 0.22 | 0.22 |
| 21 | Rye—Dakold | 0.23 | 0.27 | 0.27 |
| 22 | Rye—No. 7 | 0.24 | 0.25 | 0.22 |
| 23 | S.W.†—Pilot 13 | 0.37 | 0.45 | 0.39 |
| 24 | S.W.—H157A–4–12–8 | 0.36 | 0.32 | 0.26 |
| 25 | S.W.—Thatcher | 0.37 | 0.38 | 0.35 |
| 26 | S.W.—Sturgeon | 0.32 | 0.28 | 0.26 |
| 27 | W.W.‡—H59–13–9–5–7–12 | 0.17 | 0.18 | 0.16 |
| 28 | W.W.—Minturki | 0.12 | 0.14 | 0.15 |
| 29 | W.W.—$\frac{312.27}{29.13}$ | 0.22 | 0.26 | 0.24 |

* The products that are followed by serial numbers are experimental varieties grown by the department of agronomy.

† S.W.—Spring wheat.

‡ W.W.—Winter wheat.

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in nutrition, work should be carried out on the effect of storage on the retention of these essential nutrients.

Experiments conducted at the Iowa State College indicate that the thiamine content of ideally-stored, whole yellow corn (3) does not appear to be affected by aging even as long as four years. Studies on rice also have indicated that this vitamin is quite stable during storage. Hulled rice (4)

TABLE 2

*Riboflavin*

| No. | Material | New material, fall—1942 | One year storage, ground | One year storage, unground |
|---|---|---|---|---|
| | | *milligrams per 100 grams* | | |
| 1 | Alfalfa hay | 0.56 | 0.43 | 0.44 |
| 2 | Timothy hay | 0.54 | 0.56 | 0.51 |
| 3 | Clover hay | 0.69 | 0.56 | 0.53 |
| 4 | Alfalfa leaf meal | 1.67 | 1.61 | 1.62 |
| 5 | Cerophyll | 1.67 | 1.71 | 1.70 |
| 6 | Peas | 0.39 | 0.42 | 0.39 |
| 7 | Pea pods | 0.63 | 0.71 | 0.64 |
| 8 | Soybeans | 0.35 | 0.30 | 0.37 |
| 9 | Yellow corn | 0.16 | 0.18 | 0.17 |
| 10 | White corn | 0.15 | 0.14 | 0.13 |
| 11 | Navy beans | 0.14 | 0.14 | 0.15 |
| 12 | Oats—Vicland | 0.11 | 0.14 | 0.13 |
| 13 | Oats—Ped. No. 7 | 0.33 | 0.30 | 0.32 |
| 14 | Oats—X219–1* | 0.21 | 0.26 | 0.27 |
| 15 | Oats—CI 3662 | 0.16 | 0.20 | 0.14 |
| 16 | Oats—Erban | 0.19 | 0.23 | 0.16 |
| 17 | Barley—Ped. 38 | 0.15 | 0.15 | 0.14 |
| 18 | Barley—Ped. 5–1 | 0.22 | 0.29 | 0.20 |
| 19 | Barley—X191–2–1–2 | 0.26 | 0.27 | 0.29 |
| 20 | Rye—Imperial | 0.18 | 0.13 | 0.21 |
| 21 | Rye—Dakold | 0.28 | 0.25 | 0.23 |
| 22 | Rye—No. 7 | 0.28 | 0.26 | 0.26 |
| 23 | S.W.†—Pilot 13 | 0.18 | 0.18 | 0.25 |
| 24 | S.W.—H157A–4–12–8 | 0.21 | 0.24 | 0.24 |
| 25 | S.W.—Thatcher | 0.17 | 0.17 | 0.20 |
| 26 | S.W.—Sturgeon | 0.18 | 0.18 | 0.20 |
| 27 | W.W.‡—H59–13–9–5–7–12 | 0.18 | 0.15 | 0.20 |
| 28 | W.W.—Minturki | 0.13 | 0.15 | 0.20 |
| 29 | W.W.—$\frac{312.27}{29.13}$ | 0.17 | 0.15 | 0.17 |

* The products that are followed by serial numbers are experimental varieties grown by the department of agronomy.

† S.W.—Spring wheat.

‡ W.W.—Winter wheat.

stored in straw bags for four years retained most of its original thiamine content for the first two years, with a significant drop at the end of the third and fourth year. After storage in air-tight containers for 26–28 years, hulled rice (5) still retained 84 and 54 per cent of its original thiamine content. Hulled rice (6) stored in hermetically sealed concrete silos for five years showed no appreciable depreciation in thiamine content. A moisture content of rice (7) greater than 10 per cent causes a decrease in the thiamine

content, and the loss of vitamin runs parallel with that of viability of the seed.

Riboflavin seems to be quite stable. Fraps (3) reported that some alfalfa leaf meal which had been stored so long that almost all of the carotene had disappeared still had the same riboflavin content as is usually found in alfalfa leaf meal.

TABLE 3

*Nicotinic acid*

| No. | Material | New material, fall—1942 | One year storage, ground | One year storage, unground |
|---|---|---|---|---|
| | | *milligrams per 100 grams* | | |
| 1 | Alfalfa hay | 2.85 | 2.75 | 2.70 |
| 2 | Timothy hay | 2.35 | 2.00 | 1.94 |
| 3 | Clover hay | 2.85 | 2.95 | 2.70 |
| 4 | Alfalfa leaf meal | 4.55 | 4.30 | 3.98 |
| 5 | Cerophyll | 4.55 | 4.76 | 4.84 |
| 6 | Peas | 3.70 | 3.75 | 3.41 |
| 7 | Pea pods | 2.75 | 2.44 | 2.70 |
| 8 | Soybeans | 2.12 | 1.80 | 1.84 |
| 9 | Yellow corn | 2.32 | 2.45 | 2.38 |
| 10 | White corn | 2.36 | 2.52 | 2.38 |
| 11 | Navy beans | 1.75 | 2.07 | 2.15 |
| 12 | Oats—Vicland | 0.73 | 0.76 | 0.73 |
| 13 | Oats—Ped. No. 7 | 0.75 | 0.84 | 0.78 |
| 14 | Oats—X219–1* | 0.65 | 0.78 | 0.68 |
| 15 | Oats—CI 3662 | 0.64 | 0.68 | 0.66 |
| 16 | Oats—Erban | 0.59 | 0.69 | 0.71 |
| 17 | Barley—Ped. 38 | 4.45 | 4.44 | 4.69 |
| 18 | Barley—Ped. 5–1 | 4.46 | 4.44 | 4.58 |
| 19 | Barley—X191–2–1–2 | 4.92 | 4.89 | 5.07 |
| 20 | Rye—Imperial | 0.68 | 0.69 | 0.76 |
| 21 | Rye—Dakold | 1.27 | 1.03 | 1.00 |
| 22 | Rye—No. 7 | 1.25 | 0.75 | 1.05 |
| 23 | S.W.†—Pilot 13 | 6.52 | 6.73 | 6.54 |
| 24 | S.W.—H157A–4–12–8 | 4.52 | 5.19 | 4.90 |
| 25 | S.W.—Thatcher | 6.28 | 5.99 | 5.64 |
| 26 | S.W.—Sturgeon | 5.36 | 5.76 | 5.53 |
| 27 | W.W.‡—H59–13–9–5–7–12 | 4.36 | 4.26 | 4.77 |
| 28 | W.W.—Minturki | 5.06 | 4.40 | 4.43 |
| 29 | W.W.—$\frac{312.27}{29.13}$ | 4.72 | 4.53 | 4.38 |

* The products that are followed by serial numbers are experimental varieties grown by the department of agronomy.

† S.W.—Spring wheat.

‡ W.W.—Winter wheat.

Douglass and Richardson (1) in 1930, found that the vitamin B (complex) in carrots was not affected upon storage. In a later paper by Richardson, Langely and Andes (9) the same results were obtained.

It is obvious from the above data that very little work has been done on this particular problem. With this in mind, the following experiments were carried out. Twenty-nine air-dried plant products were obtained from the 1942 crop and assayed for riboflavin, thiamine, biotin, nicotinic acid and

pantothenic acid. The remainder of the sample was divided into two parts; part one was ground in a small feed grinder and stored in paper bags; part two was unground but stored under similar conditions. After six months storage, at room temperature, 20–25° C., the samples were reassayed for the above members of the B complex. This process was repeated after one year

TABLE 4

*Pantothenic acid*

| No. | Material | New material, fall—1942 | One year storage, ground | One year storage, unground |
|---|---|---|---|---|
| | | *milligrams per 100 grams* | | |
| 1 | Alfalfa hay | 1.58 | 1.48 | 1.49 |
| 2 | Timothy hay | 0.85 | 0.65 | 0.60 |
| 3 | Clover hay | 1.00 | 0.87 | 0.80 |
| 4 | Alfalfa leaf meal | 2.50 | 2.30 | 2.27 |
| 5 | Cerophyll | 0.69 | 0.71 | 0.74 |
| 6 | Peas | 1.01 | 0.99 | 0.98 |
| 7 | Pea pods | 0.99 | 0.95 | 0.95 |
| 8 | Soybeans | 1.24 | 1.01 | 0.96 |
| 9 | Yellow corn | 0.48 | 0.42 | 0.42 |
| 10 | White corn | 0.48 | 0.42 | 0.42 |
| 11 | Navy beans | 0.46 | 0.40 | 0.37 |
| 12 | Oats—Vicland | 0.76 | 0.54 | 0.52 |
| 13 | Oats—Ped. No. 7 | 0.99 | 0.64 | 0.64 |
| 14 | Oats—X219–1* | 0.65 | 0.56 | 0.56 |
| 15 | Oats—CI 3662 | 0.54 | 0.44 | 0.48 |
| 16 | Oats—Erban | 0.58 | 0.60 | 0.63 |
| 17 | Barley—Ped. 38 | 0.32 | 0.32 | 0.34 |
| 18 | Barley—Ped. 5–1 | 0.35 | 0.29 | 0.28 |
| 19 | Barley—X191–2–1–2 | 0.27 | 0.30 | 0.25 |
| 20 | Rye—Imperial | 0.28 | 0.26 | 0.28 |
| 21 | Rye—Dakold | 0.23 | 0.26 | 0.25 |
| 22 | Rye—No. 7 | 0.22 | 0.33 | 0.30 |
| 23 | S.W.†—Pilot 13 | 1.33 | 1.35 | 1.37 |
| 24 | S.W.—H157A–4–12–8 | 1.50 | 1.46 | 1.47 |
| 25 | S.W.—Thatcher | 1.28 | 1.56 | 1.49 |
| 26 | S.W.—Sturgeon | 1.23 | 1.27 | 1.19 |
| 27 | W.W.‡—H59–13–9–5–7–12 | 1.20 | 1.20 | 1.26 |
| 28 | W.W.—Minturki | 1.25 | 1.32 | 1.21 |
| 29 | W.W.—$\frac{312.27}{29.13}$ | 1.17 | 1.22 | 1.33 |

* The products that are followed by serial numbers are experimental varieties grown by the department of agronomy.

† S.W.—Spring wheat.

‡ W.W.—Winter wheat.

of storage. Only the data on the effect of storage for one year are reported in this paper. At six months storage no change had taken place.

## EXPERIMENTAL

The samples were first prepared for assaying by grinding in a Wiley mill. Difficulties were encountered in grinding such seed products as wheat, rye and oats. It was practically impossible to grind the outer coatings so the only part of the sample that was assayed was that portion which came

through a 40-mesh sieve. Using the above procedure the results were very low, particularly in relation to nicotinic acid and pantothenic acid. It was found that if the samples were ground in a small feed grinder, without sieving, the results checked very well with previous reports. All of the subsequent samples were prepared by grinding in the small feed mill.

TABLE 5

*Biotin*

| No. | Material | New material, fall—1942 | One year storage, ground | One year storage, unground |
|---|---|---|---|---|
| | | *millimicrograms per gram* | | |
| 1 | Alfalfa hay | 127.8 | 179.0 | 174.0 |
| 2 | Timothy hay | 32.0 | 65.7 | 66.7 |
| 3 | Clover hay | 77.0 | 94.0 | 89.0 |
| 4 | Alfalfa leaf meal | 245.0 | 330.0 | 347.0 |
| 5 | Cerophyll | 155.0 | 285.0 | 269.0 |
| 6 | Peas | 224.0 | 205.0 | 209.0 |
| 7 | Pea pods | 241.0 | 219.0 | 228.0 |
| 8 | Soybeans | 356.0 | 385.0 | 373.0 |
| 9 | Yellow corn | 54.6 | 77.0 | 85.0 |
| 10 | White corn | 73.0 | 80.0 | 80.0 |
| 11 | Navy beans | 76.3 | 120.0 | 112.0 |
| 12 | Oats—Vicland | 207.0 | 251.0 | 269.0 |
| 13 | Oats—Ped. No. 7 | 141.3 | 287.0 | 296.0 |
| 14 | Oats—X219–1* | 175.0 | 281.0 | 320.0 |
| 15 | Oats—CI 3662 | 158.7 | 294.0 | 331.0 |
| 16 | Oats—Erban | 319.0 | 301.0 | 231.0 |
| 17 | Barley—Ped. 38 | 79.6 | 231.0 | 231.0 |
| 18 | Barley—Ped. 5–1 | 106.3 | 97.0 | 97.0 |
| 19 | Barley—X191–2–1–2 | 111.0 | 81.0 | 101.0 |
| 20 | Rye—Imperial | 59.8 | 77.4 | 83.9 |
| 21 | Rye—Dakold | 61.1 | 70.0 | 74.2 |
| 22 | Rye—No. 7 | 65.1 | 60.0 | 63.0 |
| 23 | S.W.†—Pilot 13 | 69.6 | 80.8 | 83.9 |
| 24 | S.W.—H157A–4–12–8 | 44.0 | 140.0 | 139.0 |
| 25 | S.W.—Thatcher | 25.6 | 81.0 | 83.2 |
| 26 | S.W.—Sturgeon | 36.6 | 130.0 | 132.0 |
| 27 | W.W.‡—H59–13–9–5–7–12 | 65.0 | 80.0 | 92.0 |
| 28 | W.W.—Minturki | 59.5 | 70.6 | 83.0 |
| 29 | W.W.—$\frac{312.27}{29.13}$ | 68.9 | 73.0 | 64.0 |

* The products that are followed by serial numbers are experimental varieties grown by the department of agronomy.

† S.W.—Spring wheat.

‡ W.W.—Winter wheat.

Each sample was assayed for the following members of the B complex according to the accepted procedures: riboflavin (12–14), pantothenic acid (15), thiamine (2), biotin (10–11), and nicotinic acid (8–13).

## RESULTS

It is evident from the tables that no losses are encountered in these five members of the B complex upon storage. Of course, the year period of storage may not have been long enough, but we feel quite sure that under natural storing conditions these members of the B complex are stable.

It should be observed from the tables that in the case of biotin the values are higher after storage than in the original product. This can be explained by the fact that the original medium used for the assay was not complete. A factor obtained from yeast, essential for the growth of the bacteria, was not supplied in sufficient amounts. The latter analyses were made under the modified method (11).

## SUMMARY

Twenty-nine samples of plant products including hays and grains were assayed for thiamine, riboflavin, biotin, nicotinic acid and pantothenic acid. These samples were stored in the dark at 20–25° C. for one year, ground and unground, with no apparent loss of the vitamins mentioned above.

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# TESTING FOR EXTRANEOUS MATTER IN CHEESE*

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The cheese sediment test is intended to detect cheese made from unclean milk or cheese made under unsanitary conditions or both; and, second, to demonstrate to milk and cheese producers the necessity of strict cleanliness. There is a limiting factor which may interfere with the effectiveness of the test and may actually make it a deceiving instrument. When the milk is efficiently filtered or clarified in the factory then a clean cheese sediment test is not necessarily indicative of a satisfactory milk supply.

It is general practice in the industry to inspect cheese sediment tests and to classify them according to certain arbitrary standards. The grades generally used are Good, Fair, Poor and Illegal and are numbered 1, 2, 3 and 4, respectively, to correspond, presumably, with the four grades of milk sediment tests commonly recognized in milk manufacturing areas.[1] Milk sediment tests are classified only by amounts of sediment visible to the unaided eye but cheese sediment tests are also examined microscopically for material of insect or animal origin before the tests can be properly classified.

## METHODS OF MAKING TESTS FOR EXTRANEOUS MATTER IN CHEESE

Two procedures are commonly used for testing cheese for extraneous matter; one test requires sodium citrate (2) as a solvent while the other employs orthophosphoric acid (3). A third test was developed by Dr. Chernoff in the Denver Station of the Food and Drug Administration (1); it has not found application in commercial practice. A modification of the sodium citrate test is probably most commonly followed at present.

It is our purpose to discuss the commonly used tests and some of the problems of interpreting and applying them in commercial practice. In table 1 are shown the essential characteristics of the phosphoric acid test and the original and modified forms of the sodium citrate tests.

The sediment discs from the test are graded macroscopically and are examined with a low-power microscope to detect the presence of critical foreign matter of animal or insect origin.

It is impossible to identify or even to discover some types of critical extraneous material, such as fine hairs, for example, without some magnification. This fact is illustrated by a series of 1,102 extraneous matter tests.

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[1] The State of Illinois, Division of Foods and Dairies, 228 South Wabash Avenue, Chicago, Illinois, published a pamphlet in 1942 which illustrates both milk sediment and cheese sediment standards of this type.

The tests were first examined carefully with the naked eye and 9 of them were given a grade of 4, a grade which is an indication of excessive quantities of extraneous material or the presence of critical material such as rodent hair, cow hair or insect parts. When the same 1,102 tests were examined with 85 × magnification 481 sediment pads were graded 4. Visual inspection of cheese sediment tests must always be supplemented with microscopic examination if the test is to serve its fullest usefulness in identifying and correcting sources of contamination.

TABLE 1

*Methods of detecting extraneous matter in cheese*

| | Methods | | |
|---|---|---|---|
| | Original sodium citrate | Modified sodium citrate | Phosphoric acid |
| 1. Size of sample | 100 gm. | 225 gm. (8 oz.) | 50 gm. |
| 2. Type of solvent | Sodium citrate | Sodium citrate | Orthophosphoric acid |
| 3. Strength of solvent | 150 gm. in 1000 ml. of water | 100 gm. in 1000 ml. of water | 7 ml. in 1000 ml. of water |
| 4. Amount of solvent | 300 ml. | 800 ml. | 500 ml. |
| 5. Solvent contact before heating | None | Overnight | None |
| 6. Temperature of heating | 140° F. | 150° F. | Boiling |
| 7. Duration of heating | About 30 min. | About 45 min. | Until dissolved |
| 8. Agitation | Vigorous | Vigorous | Occasional |
| 9. Filter disc | Reversed 1¼" milk-sediment disc | | 1¼" Irish poplin disc* |
| 10. Filtering surface of disc | One-inch circle | One-inch circle | One-inch circle |
| 11. Filtering device | Pressure or vacuumatic milk sediment tester | | |

* The Irish poplin is used over a milk sediment pad.

## USING THE MICROSCOPE TO ESTIMATE THE AMOUNT OF EXTRANEOUS MATTER ON SEDIMENT DISCS

The idea of grading sediment pads by numbers of particles of extraneous matter was investigated. For counting particles of extraneous matter a low-power, binocular microscope was used; its three objectives provided magnifications of 21.2, 42.5 and 85 diameters. A jig for holding a sediment pad was placed in the clamps of the mechanical stage so that it was possible to examine the entire surface of the pad systematically in a minimum of time.

The actual counting operation was facilitated by the use of a reticule in the eyepiece of the binocular that was ruled into squares and served to mark off the boundaries of a definite area of the microscopic field; this area was measured. The known area of the filtering surface of the sediment pad

divided by the measured area in the microscopic field gave a factor which, when multiplied by the average count per field, gave an estimate of the number of particles on the sediment pad. The average count of particles per field was based upon the counting of approximately 20 fields.

Experiments, which need not be described in detail, showed that macroscopic grades are related to numbers of particles but the labor involved does not justify microscopic counting for commercial grading. The method was very useful in some phases of this study.

### FILTERING MATERIALS FOR EXTRANEOUS MATTER TESTS

Careful microscopic examination of the reversed, milk-sediment discs indicated that short segments of hairs and fine particles of extraneous matter may become so deeply imbedded even in the compact side of the discs that undoubtedly some must escape detection altogether. Irish poplin was found

TABLE 2

*Comparison of the retaining power of the reversed milk sediment disc and Irish poplin disc*

| Sample number | Solvent | Number of particles from 50 grams of cheese | | Ratio of counts on the two types of sediment discs |
|---|---|---|---|---|
| | | Irish poplin disc | Milk sediment disc | |
| | | | | (poplin : milk disc) |
| 1 | Acid | 7812 | 1220 | 6 : 1 |
| 2 | Acid | 18648 | 1465 | 13 : 1 |
| 3 | Acid | 16632 | 1720 | 10 : 1 |
| 4 | Citrate | 6552 | 722 | 9 : 1 |
| 5 | Citrate | 16632 | 2050 | 8 : 1 |
| 6 | Citrate | 14868 | 2210 | 7 : 1 |
| 7 | Citrate | 16632 | 2440 | 7 : 1 |

to be more satisfactory when used over the usual milk sediment disc. This closely woven cloth provides a relatively smooth surface on which extraneous matter can be examined microscopically with a minimum of focusing. One disc of Irish poplin clogs before eight ounces of dissolved cheese can be filtered through it but with a 50-gram sample it rarely if ever gives any trouble.

A measure of the hiding effect of the milk sediment disc is indicated in table 2 which shows the number of visible particles of sediment appearing on both types of filters when samples of the same size from identical cheese are tested. In these trials the poplin discs revealed 6 to 13 times as many particles under 85 × magnification as the reversed milk sediment discs. This ratio tends to vary with the type and size of extraneous matter particles in the cheese. When the Irish poplin pad is used it has the practical effect of making the results of the test with the 50-gram sample of cheese equivalent to a larger sample filtered through a reversed milk sediment disc.

EFFECTS OF SOLVENTS ON EXTRANEOUS MATTER

Spicer and Price (2) observed no marked effect on common types of extraneous material surviving their test nor after treating the cheese with the citrate solvent for 18 hours at 37° C. This type of soaking period is now commonly used in commercial laboratories to hasten the period of solution when the sample is placed in the heating bath. Turner, Rogers and Conquest (3) stated that cellulose, chitin and inorganic types of extraneous matter lost approximately 5 per cent of their weight during 20 minutes of boiling in the one per cent orthophosphoric acid solution, and furthermore, that their structures were not visibly altered.

TABLE 3

*The influence of type of solvent on extraneous matter*
(Sodium citrate, 10% solution; orthophosphoric acid, 1% solution)

| Type of extraneous material* | Solvent | Amount of solvent | Maximum temperature | Duration of heating | Proportion dissolved |
|---|---|---|---|---|---|
| | | *ml.* | *° F.* | *min.* | *%* |
| Milk sediment | Citrate | 200 | 150 | 15 | 33 |
| | Acid | 500 | 212 | 15 | 51 |
| | Water | 160 | 212 | 15 | 16 |
| Cow dung | Citrate | 200 | 150 | 15 | 20 |
| | Acid | 500 | 212 | 15 | 22 |
| Timothy hay | Citrate | 200 | 150 | 15 | 7 |
| | Acid | 500 | 212 | 15 | 18 |
| Oat hulls | Citrate | 200 | 150 | 15 | 20 |
| | Acid | 500 | 212 | 15 | 30 |
| Hay and grain mixture | Citrate | 800 | 150 | 30 | 21 |
| | Acid | 500 | 212 | 15 | 27 |
| Iron filings | Citrate | 200 | 150 | 15 | 6 |
| | Acid | 500 | 212 | 15 | 100 |

* Extraneous material was dried at 100° F. before weighing both before and after solvent action.

During this study such materials as hair, dust, insect parts, brush bristles, spider web, wood splinters, metal, grease from an agitator, and cotton threads from bandages have been subjected to the conditions and solvents of each test. These materials in general have been recovered after the treatments in identifiable amounts with the exception of cotton bandage threads which were dissolved by the sodium citrate solvent; agitator grease, which was dissolved by both solvents and iron particles which were dissolved by the acid. Both solvents were found to have some dissolving action on common materials such as those shown in table 3. The substances shown in this table were subjected to treatments approximating those of the actual tests; no cheese was present in the solutions during the treatments.

Table 3 indicates that the phosphoric acid solvent always tends to dissolve a little more of the organic matter than the citrate and attacks iron

strongly. Despite the amounts of the substances dissolved by either test there still remained on the filter pads enough of the substances for identification and observation. It is interesting to observe that even boiling water has a marked action on samples of dried milk-sediment taken from a factory filter cloth.

The conditions of the treatments shown in table 3 are probably more severe than those to which these substances would ordinarily be exposed in the extraneous matter test. In making the test the cheese itself acts as a protecting cover for at least a portion of the extraneous matter while the cheese is being dissolved; then, as soon as possible after the cheese is dispersed, the solution is filtered.

Sodium citrate is distinctly less active toward metals than the phosphoric acid. This fact is important in the choice of materials used for handling the cheese and phosphoric acid solvents while testing for extraneous matter. A poorly tinned or copper sediment tester may contribute so much dissolved metal to the acid solution that the sediment pad may be practically worthless as an indication of the condition of the cheese.

### THE INFLUENCE OF CONTINUED HEATING UPON EXTRANEOUS MATERIAL

There is a possibility that the extraneous matter in cheese might dissolve if the duration of the heat treatment were increased as is sometimes necessary to obtain complete dispersion. This question was studied by grinding up several pounds of cheese, dividing it into several portions and finally subjecting these portions to four different heat treatments with each of the two solvents. During the treatment with sodium citrate the cheese-solvent mixture was stirred gently while being held at the usual 150° F.; with phosphoric acid the slow boiling of the mixture furnished the only agitation. All mixtures were filtered through Irish poplin and the particles of extraneous matter were counted under 85× magnification. The results are shown in table 4.

TABLE 4

*The influence of the duration of the heat treatment on the extraneous matter*

| Duration of heating | Average number of particles on poplin pads | |
|---|---|---|
| | Sodium citrate solvent | Phosphoric acid solvent |
| 0.5 hour | 7,790 | 11,220 |
| 1.0 hour | 8,970 | 12,200 |
| 1.5 hours | 7,380 | 11,680 |
| 2.0 hours | 8,010 | 11,170 |

The data in table 4 show that prolonging the heat treatments does not apparently change the results of the tests. If there is a tendency for the continued action of the solvents to dissolve the extraneous matter it is not

revealed by counting the number of particles remaining on the filter discs; neither is it apparent to the naked eye in the discoloration of the filter discs.

The data in table 4 also show a distinctly larger number of particles revealed by the phosphoric acid treatment. This suggested the necessity of further observations of the effect of solvent on numbers and size of sediment particles.

### INFLUENCE OF SOLVENTS UPON THE SIZE AND NUMBER OF PARTICLES OF SEDIMENT REMAINING ON THE SEDIMENT PADS AFTER FILTERING

Occasional sediment tests with sodium citrate seem darker than tests made with phosphoric acid on identical samples of cheese. Such effects might be caused by differences in the size or number of particles surviving the test treatments.

TABLE 5

*Influence of solvents on size of particles of sediment*

| Cheese sample number | Average diameter of particles in 10 random fields | | | | | |
|---|---|---|---|---|---|---|
| | 50-gram samples on poplin | | | 8-oz. samples on milk filter | | |
| | Sodium citrate | Phosphoric acid | Difference (Citrate – Acid) | Sodium citrate | Phosphoric acid | Difference (Citrate – Acid) |
| | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* | *mm.* |
| 1 | 0.074 | 0.060 | 0.014 | 0.096 | 0.050 | 0.046 |
| 2 | 0.066 | 0.045 | 0.021 | 0.088 | 0.068 | 0.020 |
| 3 | 0.060 | 0.038 | 0.022 | 0.088 | 0.097 | – 0.009 |
| 4 | 0.060 | 0.036 | 0.024 | 0.084 | 0.092 | – 0.008 |
| 5 | 0.058 | 0.048 | 0.010 | 0.062 | 0.058 | 0.004 |
| 6 | 0.054 | 0.044 | 0.010 | 0.086 | 0.084 | 0.002 |
| 7 | 0.072 | 0.033 | 0.039 | ..... | ..... | ..... |
| Average | 0.063 | 0.043 | 0.020 | 0.084 | 0.0748 | 0.009 |

*Size.* Measurements were made of size of particles by using both sediment tests on identical samples of cheese. Some of the tests were 50-gram samples filtered through poplin discs, others were 8-ounce samples filtered through milk sediment discs. Each disc was placed under the microscope and the longest dimension of the particle nearest the center of each field was recorded. Ten fields on each disc were selected at random and particles were so measured; the average of these measurements is shown in table 5.

It is apparent that when the poplin filter pad is used the particles resulting from the phosphoric acid treatment are about two-thirds the size of those remaining after the sodium citrate treatment. When the milk filter disc is used the average size of particles is larger and practically the same for both solvents. Here again the hiding effect of the milk sediment disc is indicated.

*Number.* In table 6 are shown numbers of particles from equal amounts of identical cheese tested with each solvent. Samples 1 to 8 in table 6 were filtered on Irish poplin; the citrate test showed approximately 1 particle to

each 1.8 particles from the test with acid; when the reversed, milk-sediment, filter disc was used for samples 9 to 13 then the ratio of counts averaged practically 1 to 0.9.

Such differences in the ratio of numbers of particles resulting when the two solvents are used can be explained by the tendency of the acid to break up and so reduce the size of particles. The poplin filter disc retains the finer particles on its surface so that the number visible is distinctly greater than that resulting when the milk sediment disc is used. On the other hand, the finer particles penetrate the loose structure of the milk sediment disc leaving a proportionately greater number of large particles visible. On the

TABLE 6

*The influence of the solvent on the number of particles of extraneous matter*

| Sample number | Number of particles from 50 gms. of cheese | | Ratio of counts (citrate : acid) |
|---|---|---|---|
| | Sodium citrate | Phosphoric acid | |
| | Irish poplin filter disc | | |
| 1 | 16,130 | 29,480 | 1 : 1.8 |
| 2 | 12,850 | 27,720 | 1 : 2.2 |
| 3 | 17,890 | 24,440 | 1 : 1.4 |
| 4 | 12,820 | 19,150 | 1 : 1.5 |
| 5 | 14,870 | 18,650 | 1 : 1.3 |
| 6 | 16,630 | 28,980 | 1 : 1.7 |
| 7 | 7,310 | 17,640 | 1 : 2.4 |
| 8 | 7,060 | 15,120 | 1 : 2.1 |
| | Reversed milk sediment disc | | |
| 9 | 2,440 | 1,720 | 1 : 0.7 |
| 10 | 2,220 | 1,460 | 1 : 0.7 |
| 11 | 2,420 | 1,550 | 1 : 0.6 |
| 12 | 1,250 | 1,140 | 1 : 0.9 |
| 13 | 2,250 | 3,276 | 1 : 1.5 |

Irish poplin the acid test may show the darker appearance depending somewhat on the type and color of the finely divided extraneous matter present in the cheese but on the reversed milk-sediment pad the citrate test is apt to show the darker color.

### ESTIMATING SEDIMENT GRADES BY MACROSCOPIC EXAMINATION

Three judges were asked to grade unidentified sediment test discs drawn at random from 237 obtained by analyzing three samples from each of 79 cheddars making up 8 different lots of cheese. The summary of their estimates is presented in table 7 which shows the macroscopic grade for each lot determined by the majority of each judge's votes and the proportion of his votes disagreeing with his majority. The proportion of "maverick" votes indicates the variability of each lot in the opinion of that judge.

The judges did not agree either in their estimates of the uniformity of the samples from each lot of cheese or on the grades of the lots themselves. It is obvious that variations in samples from lots as well as variations in judges' opinions are involved. The judges indicated that unanimous agreement would be impossible when grading unidentified sediment test discs; one reason was the "border-line" samples which might be called one grade one time and another grade at another inspection; another reason was the pesonal factor which included speed of examination, eyesight, leniency, distractions while judging, light conditions, and finally the experience of the judge. Experience in judging discs however does not contribute necessarily to the uniformity of the results because Judge A in table 7 was by far the most experienced of the three.

TABLE 7

*Variability of judges in estimating grades by macroscopic examination*

| | Size of test sample | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 50-gm. sample | | | | | 8-oz. sample | | |
| Lot number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Number of cheddars | 4 | 12 | 10 | 10 | 9 | 10 | 12 | 12 |
| Discs judged | 12 | 33 | 30 | 30 | 27 | 30 | 36 | 36 |
| Judge | Sediment grades indicated by majority votes | | | | | | | |
| A | 2 | 2 | 2 | 3 | 3 | 4 | 2 | 2 |
| B | 3 | 3 | 2 | 3 | 4 | 4 | 2 | 2 |
| C | 3 | 2 | 2 | 3 | 3 | 4 | 2 | 2 |
| Judge | Proportion of votes in the minority | | | | | | | |
| | % | % | % | % | % | % | % | % |
| A | 25.0 | 8.3 | 23.3 | 23.3 | 51.8* | 43.3 | 13.9 | 8.3 |
| B | 16.7 | 41.7 | 10.0 | 20.0 | 37.0 | 26.6 | 0.0 | 2.8 |
| C | 0.0 | 45.5 | 6.7 | 11.1 | 48.2 | 43.3 | 19.4 | 25.0 |

* Over half of votes can be in the minority when all votes are distributed between more than two grades.

## SAMPLING

The sample of cheese for sediment test must be removed from the lot in such amounts and in such a manner that it is typical of the whole lot. The removal of such a sample depends upon the uniformity of distribution of sediment between the individual cheeses constituting the lot and within each individual cheese.

*Distribution of sediment within the individual cheese.* The distribution of sediment within the individual cheese was studied by taking samples from three portions of each cheddar of eight different lots of cheese—a total of 79

cheddars. Each cheddar was sampled in three zones—top, bottom and center. Samples were obtained from the top and bottom by inserting a cheese trier obliquely into the flat surface at points midway between the center and circumference; the center sample was taken by inserting a butter trier straight down through the axis of the cheddar and removing the necessary amount from that portion of the plug nearest the center of the cheese. Fifty-gram samples were taken from 5 lots of 48 cheddars; they were tested by the phosphoric acid method, filtered through poplin and then mounted on sediment test cards under cellophane. Eight-ounce samples were taken from 3 lots of 31 cheddars; they were tested by the sodium citrate method, filtered on reversed milk sediment discs and then mounted on cards under cellophane. Judges were required to mix all cards from all cheddars into one pile from which tests were drawn and classified before any identifying marks were disclosed.

TABLE 8

*The distribution of sediment discs from 3 sections of cheddars by visual grading of three judges*

| Judge | Number of cheddars | Number of discs judged | Minority votes | | Distribution of minority vote | | |
|---|---|---|---|---|---|---|---|
| | | | Number | Per cent | Top | Center | Bottom |
| A | 79 | 237 | 55 | 23 | 20 | 22 | 13 |
| B | 79 | 237 | 45 | 19 | 10 | 20 | 15 |
| C | 77 | 231 | 62 | 27 | 19 | 25 | 18 |
| Totals | 235 | 705 | 162 | 23 | 49 | 67 | 46 |

The results of the classification of sediment tests are shown in table 8. The cheddars of each lot were regarded as a group and all sediment tests on that lot were used to determine the judge's grade of the lot. The grade of the lot was fixed by the majority of the judge's estimates of all tests on the lot. The estimates of grades in the minority ("mavericks"), are divided in table 8 according to the section from which the test was obtained.

Theoretically, if the extraneous matter were distributed evenly then the number of "mavericks" should be the same in each class. Out of a total of 705 sediment discs classified by the three judges, 162 were "mavericks." Of this 162, 49 samples were taken from the top, 67 from the center and 46 from the bottom of the cheddars. According to the chi-square test, this distribution is unusual but not significantly different from the equal number which was expected in each section. When the votes of the individual judges are considered by the same chi-square test it is clear that, as individuals, they found no single section producing significantly more "mavericks" than any other section.

Another attempt was made to discover, if possible, any tendency for the extraneous matter to occur in one of the three sections of these lots of cheese under discussion. This was done by estimating, under 85 × magnification,

TABLE 9

*Number of particles on poplin sediment discs from tests of three sections of cheddars*

| Section of cheese | Number of cheese | Numbers of sediment particles | | | |
|---|---|---|---|---|---|
| | | Minimum | Maximum | Average | Standard deviation |
| Top | 48 | 13,104 | 41,832 | 27,292 | 7,350 |
| Center | 48 | 14,112 | 45,864 | 26,875 | 7,250 |
| Bottom | 48 | 11,844 | 45,612 | 28,645 | 8,185 |

the number of particles of sediment on Irish poplin sediment discs obtained from five lots, totaling 48 cheddars. The results are shown in table 9. Typical data for all cheese in a single lot are shown in table 11.

The average number of particles of sediment on the discs from each of the three sections of the cheddars are practically identical, according to evidence in table 9. The ranges of average numbers of particles observed in each section are very similar. The variability of the data is also indicated by the magnitude of the standard deviations.

For all practical purposes it makes no difference in testing cheddars for extraneous matter whether the samples are taken from the top, center or bottom sections.

*Distribution of sediment between cheese in the lot.* The distribution of sediment between cheese constituting individual lots (vats) was not uniform as determined by microscopic counts of particles. Results of counts are summarized in table 10.

It has been shown that the distribution between sections of a cheese is uniform so that data from the top section of the cheese are used in table 10 to illustrate the variations between cheese. Median values in lots 1, 2 and 4 are practically identical; the range of counts indicated by minimum and maximum values in these three lots include the median values of the other two lots, 3 and 5, and almost include the extremes as well.

As further evidence of this lack of uniformity of distribution of extraneous matter, table 11 is presented. In this table is shown the number of particles of sediment in the top, center and bottom sections of the 12 ched-

TABLE 10

*Distribution of extraneous matter between cheese in the lot*

| Lot number | Number of cheese | Number of particles in top section (50-gm. sample) | | |
|---|---|---|---|---|
| | | Minimum | Maximum | Median |
| 1 | 12 | 20,160 | 38,050 | 25,830 |
| 2 | 8 | 19,908 | 31,248 | 25,956 |
| 3 | 10 | 13,104 | 20,916 | 17,514 |
| 4 | 10 | 21,420 | 34,776 | 25,964 |
| 5 | 9 | 27,468 | 43,344 | 33,516 |

dars constituting one lot or vat of cheese. Variations in counts in the three sections within individual cheese approximate 3500 particles; between individual cheese the range is from 19,000 to 39,000.

TABLE 11

*Distribution of sediment in a typical lot of cheese*

| Cheese number | Number of particles in samples (000 omitted) | | |
|---|---|---|---|
| | Top | Center | Bottom |
| 1 | 35 | 33 | 30 |
| 2 | 34 | 33 | 33 |
| 3 | 38 | 39 | 39 |
| 4 | 35 | 37 | 36 |
| 5 | 25 | 32 | 30 |
| 6 | 26 | 34 | 32 |
| 7 | 25 | 24 | 31 |
| 8 | 23 | 25 | 24 |
| 9 | 20 | 21 | 21 |
| 10 | 20 | 19 | 24 |
| 11 | 27 | 27 | 25 |
| 12 | 25 | 23 | 31 |

Macroscopic examination of sediment tests from every cheese in a single lot revealed definite differences in amounts of extraneous matter. In table 12 the ratings of one experienced judge are used. All sediment discs were made from samples from the top sections of each cheese in each lot.

The sediment tests on these 50-gram samples of different cheese in the same lot indicate that more extraneous matter can be expected in some cheese than in others. Two lots in table 12 show discs in three of the four possible grades, two lots, in two grades, and one lot shows discs in only one grade. Although these samples were judged on poplin discs through which had been filtered only 50 grams of cheese, similar results might have been shown after using the 8-ounce sample and the reversed, milk-sediment, disc.

TABLE 12

*Macroscopic grades* of sediment tests (50-gm. samples) from top section of individual cheese*

| Lot number | Number of cheese | Distribution of cheese between grades | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| 1 | 12 | 0 | 10 | 2 | 0 |
| 2 | 5 | 0 | 2 | 3 | 0 |
| 3 | 10 | 10 | 0 | 0 | 0 |
| 4 | 10 | 0 | 2 | 7 | 1 |
| 5 | 9 | 0 | 1 | 4 | 4 |

* Only the grades of Judge A are tabulated.

## SIZE OF SAMPLE

A sample of satisfactory size should detect the presence of critical material with regularity if it is present and should reveal excessive contamination

in convincing amounts for factory demonstration purposes. In table 13 are summarized the results of paired tests on identical cheese; one test was made using the eight-ounce sample while the other was made with the 50-gram sample. These are the two most commonly used samples in commercial practice.

Table 13 indicates that the 50-gram sample detected the presence of critical material in 37 out of a total 211 samples while the 8-ounce sample detected it in 76. Factories E to H in table 13 indicate irregularity in the ability of both sample sizes to detect critical extraneous material; in some instances one revealed it but the other did not. In the 122 paired tests made on factories A and B, the 8-ounce sample detected critical material in 44 samples in which none was found by the 50-gram sample; the 50-gram sample

TABLE 13

*Relative efficiency of 50-gm. and 8-ounce samples for detecting critical material in cheese*

| Factory | Paired tests on identical cheese | Tests showing critical material* under 85 × magnification | | | |
|---|---|---|---|---|---|
| | | 50-gm. sample | | 8-ounce sample | |
| | | *Number* | % | *Number* | % |
| A | 55 | 20 | 36 | 44 | 80 |
| B | 67 | 10 | 15 | 25 | 37 |
| C | 21 | 2 | 10 | 1 | 5 |
| D | 24 | 1 | 4 | 2 | 8 |
| E | 19 | 2 | 10 | 0 | 0 |
| F | 10 | 0 | 0 | 4 | 40 |
| G | 9 | 0 | 0 | 0 | 0 |
| H | 6 | 2 | 33 | 0 | 0 |
| Totals ..... | 211 | 37 | 17.5 | 76 | 36 |

* Critical material = material of insect or animal origin.

detected critical material in 9 samples in which the 8-ounce sample failed to catch any. In general, table 13 indicates that the 50-gram sample is half as effective in detecting critical material when 20 per cent or more of the lots tested with this size sample are defective.

It is not necessary to extend this discussion to show detailed comparisons of macroscopic grades of identical cheese tested by using samples of each size. Both are effective tests for control purposes when used with suitable guides made up with actual sediment discs; photographs of such guides are not effective standards. The 8-ounce sample is slightly more uniform because of the greater amount of sediment collected and because of the standardizing effect on particle size of the milk-sediment filter.

The Food and Drug Administration was first to use an 8-ounce sample of cheese; personal conferences with officials of this Administration indicated that this sample was not regarded as either a minimum or a maximum. Although the first reaction of the cheese industry was unfavorable, because of the damage which such large samples would cause when taken from the

cheese, this amount of sample was generally adopted by commercial laboratories with a few exceptions. Two methods of obtaining 8-ounce samples for routine testing were devised which decreased materially the losses caused by plugging the cheese. The first method used a special knife devised by E. Bohacek of the Lakeshire-Marty Company, Plymouth, Wisconsin. This knife cuts an eight-ounce, V-shaped strip of cheese from the flat surface of a cheddar. The cut surface is easily sealed by the paraffining of the cheese. The second method of sampling requires the cooperation of the cheese maker, who is instructed to take a sample of curd just before pressing. This curd, which should be taken from the hoops, is packed solidly into a jar provided with an air-tight closure. If the jar is completely filled and closed the sample can be sent to the warehouse laboratory along with the cheese shipment without danger of spoilage.

Since 50 grams of cheese approximates the yield of cheese from a pint of milk, the amount used in a milk sediment test, it has been suggested (2) that milk sediment standards might be used for judging cheese sediment tests. Factory operations, however, may introduce sediment and Wartinbee (4) reported appreciable amounts of sediment in the whey at dipping; all of which would seem to indicate that the relationship between milk and cheese sediment tests might be misleading.

### IDENTIFICATION OF EXTRANEOUS MATERIAL ON THE CHEESE SEDIMENT TEST

Identification of extraneous material should classify the material as critical or non-critical. Critical materials are insects or substances of animal origin. Vegetable matter or debris under certain circumstances might also be classed as critical material. Non-critical materials, which, if they are present in appreciable amounts, are indicative of unsatisfactory conditions of milk production or cheese manufacture or both, include: vegetable matter, soil particles, dust, ash, cloth fibers and wood or metal particles.

All types of hair and wool are relatively easy to identify. While hairs of any type are considered critical, hairs from rats and mice are particularly objectionable. Such hairs are distinguished by characteristic markings but it is possible to find hairs from dogs, cats, squirrels and rabbits which so closely resemble rodent hairs that they are practically indistinguishable from them.

Insects or insect parts are critical materials which can be identified more easily if the original insects have been examined carefully. Insects which may be encountered are flies and fly larvae (especially in the soft rinds of cheese like Limburger), cockroaches, centipedes, silverfish, sow bugs, spiders and cheese mites. Insects are chiefly found where poor housekeeping practices prevail.

Cloth fibers which are very apt to appear in cheese sediment tests are the blue cotton fibers from denim overalls. Brightly colored wool fibers prob-

ably come from sweaters worn by those working on the farms or in the factories.

Particles of soil, dust, coal dust, soot, cinders, wood or tobacco ashes may appear on sediment discs. Their origins are obvious and indicate the necessity of better care in the production of the milk or in factory operations. An open window in a factory where smoke from the boiler or dust from a plowed field or dusty road can blow into the plant may easily be responsible for a Number 4 sediment test.

Metal particles, curiously enough, are frequently seen on cheese sediment tests. Probably most of them have their origin in the stirring of milk during cooling but factory operations may also be blamed through scraping of metal equipment and utensils in the making of the cheese. Such contamination might come from knives drawn across the vat, mechanical agitators, curd forkers, curd mills, scoops, rubbing of hoops in the vat and the like.

It is not practical to reproduce here pictures of all kinds of extraneous material which might get into cheese. A fairly complete series of such photographs[2] has been prepared at this laboratory from which prints can be obtained by anyone who is interested in building up a collection to assist in the identification of extraneous matter.

## SUMMARY

The test for sediment in cheese detects unsatisfactory conditions of milk and cheese production except when the milk supply is filtered efficiently. The results of the test may be graded by macroscopic appearance but should also be examined microscopically for critical material.

The two practical tests use solutions of either sodium citrate or orthophosphoric acid. Commonly eight ounces of cheese is used with the citrate test while 50 grams of cheese is used with the acid solvent. The larger sample must be filtered through a reversed, milk-sediment disc while the smaller sample is most effective when a filter of Irish poplin is used over a milk sediment disc. The smooth surface of poplin can be examined more easily with a microscope since it retains all particles in view; the milk-sediment disc tends to hide all small particles of sediment.

There is not much to choose between the solvents although the acid seems to work faster on young cheese. Neither solvent, under the conditions used in making the tests, destroys enough of the common types of extraneous material to prevent identification although both attack such material more or less. The acid tends to reduce the size and increase the number of sediment particles.

The distribution of extraneous material seems to be fairly uniform within a single cheese but from cheese to cheese from a single lot the distribution is

[2] An index of photographs available for distribution will be sent on request by the Department of Dairy Industry, University of Wisconsin, Madison 6, Wisconsin.

not uniform. Such irregularity makes it desirable to take plugs from several cheese in each lot and essential to test the cheese from a given outlet regularly and as frequently as possible.

The identification of extraneous material by microscopic examination of test pads may provide a useful method of determining sources of contamination. Photographs of common types of extraneous matter which are available for distribution from this laboratory may prove helpful in this respect although they cannot replace microscopic study of the actual material from local sources.

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# ABSTRACTS OF LITERATURE

## BOOK REVIEW

**334. The Chemistry and Technology of Food and Food Products.** Edited by MORRIS B. JACOBS, published by Interscience Publishers, Inc., 215 Fourth Ave., New York, N. Y. Volume 1, XVIII, 952 pages, 79 illustrations, 218 tables, $10.50.

This, the first of two volumes on the title subject, contains 23 chapters prepared by 21 collaborators. The subject matter is divided into two parts: (a) fundamentals dealing with aspects of food chemistry common to all foods, (b) some account of the history, statistics, definitions, standards, composition, and chemistry of these food groups. The section on fundamentals includes: physical chemistry as applied to foods, and the instruments for measuring their physico-chemical properties (38 pages); chemistry, properties and uses of carbohydrates (36), lipids (19), amino acids and proteins (72), enzymes (41), vitamins, vitagens, hormones (40), mineral matters and inorganic food adjuncts (27), coloring matters (18); digestion and fate of foodstuffs (26); food spoilage and poisoning (24). The second part of the volume contains chapters dealing with classes of food products including dairy (39), meat (35), fish (39), poultry and eggs (18), oils and fats (21), cereal grains (89), bakery foods (40), vegetables, mushrooms, nuts and fruits (46), carbohydrate and sugar foods (24), confectionery and cacao (27), coffee and tea (16), spices, flavor and condiments (22).

For the most part these latter chapters do not include the details of processing techniques, which are evidently reserved for a second volume; but they do contain excellent reviews of problems and procedures specific and peculiar to the products, which the respective authors considered significant to that particular branch of the food industry. As a result much information useful in the arts of food technology has been assembled. On the other hand, some of the material is arranged in a technical dictionary descriptive style and as a result is brief and elementary. Even though several texts have appeared in recent years in the various fields of food technology, the approach to the subject as indicated in this first volume is different, and with breadth, and should prove a valuable correlative book in food laboratories and operations. While the section on dairy products in this volume contains no information not already available in the usual dairy texts, and is somewhat brief and elementary for those engaged in dairy industries work, the scope of the material in the balance of the text and the reference to milk in connection with other products make it a valuable augmentative text also to the dairy food industry. K.G.W.

## BACTERIOLOGY

**335. Riboflavin Requirements of Certain Lactic Acid Bacteria.** THRESSA E. CAMPBELL AND G. J. HUCKER, N. Y. Agr. Expt. Sta., Geneva, N. Y. Food Res., *9*, No. 3: 197. May–June, 1944.

Studies were made of the riboflavin requirements of a large number of lactic acid bacteria. One culture, No. 7993 (*Lactobacillus*), was encountered which responded to smaller quantities of riboflavin than No. 7496 (*L. Casei*), presently used as the assay organism. Studies indicated that this culture (7993) could be used for assaying materials too low in riboflavin to be accurately assayed with culture 7496, *i.e.*, in the range of 0.01 to 0.10 micrograms per five milliliters. F.J.D.

**336. Relative Resistance of *Eberthella typhosa* and *Escherichia coli* to Chlorine and Chloramine.** ELSIE WATTIE AND C. T. BUTTERFIELD, Dept. of Water and Sanitation Investigations, U. S. Public Health Service, Cincinnati 2, Ohio. Jour. Bact., *47*, No. 5: 444–445. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

At normal pH ranges, when chlorine is the disinfecting agent, approximately 60 times as much residual chlorine as chloramine is required to produce the same extent of kill as free chlorine in the same interval of time. To secure the same extent of kill with chloramine in the same concentration as free chlorine requires approximately 20 to 30 times as long an interval for chloramine. D.P.G.

**337. The Temperature Coefficient of the Bactericidal Action of Chlorine.** ADA MAE AMES AND WINSLOW WHITNEY SMITH, Univ. South. Calif., Los Angeles. Jour. Bact., *47*, No. 5: 445. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

More than nine times as long is required for a given dose of chlorine to disinfect water at 8° as at 40°. (The Centigrade scale is inferred.) D.P.G.

**338. A Proposed Standard Method for the Bacteriological Examination of 30–40 Mesh Edible Gelatin.** MURRAY P. HORWOOD, Mass. Inst. Technol., Boston, Mass. Jour. Bact., *47*, No. 5: 436. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

Following a study of methods, it is recommended that the bacteriological examination of fine ground edible gelatin be made on one per cent solutions, on tryptone glucose agar, at 35–37° C. after 48 hours. D.P.G.

**339. Heat Activation Inducing Germination in the Spores of Thermophilic Aerobic Bacteria.** HAROLD R. CURRAN AND FRED R.

EVANS, U. S. Dept. Agr., Bur. Dairy Indus., Agr. Res. Admin., Washington, D. C. Jour. Bact., *47*, No. 5: 437. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

Of 10 facultative thermophilic cultures isolated from spoiled commercially-canned evaporated milk, nearly all responded to preincubation heat. A large proportion of the potentially viable spores did not germinate in the absence of such treatment. The procedure consisted of seeding washed spores into various substrates and heating at 95° C. for 10 minutes; the heated and control suspensions were then subseeded into glucose nutrient-agar plates which were incubated at selected temperatures and counted after 48 hours.

The proportion of spores which responded to a preincubation heat stimulus was found to be dependent upon the amount of heat, the nature of the heating medium, the temperature at which the spores were formed, and the temperature at which they were subcultured. As heating mediums, 0.5 per cent glucose or lactose were more effective upon heat activation than were 0.5 per cent peptone, milk, glucose nutrient-agar, beef-extract (0.3 per cent), glucose nutrient-broth, distilled water, or 0.5 per cent NaCl. D.P.G.

## BUTTER

**340. The Viability of Certain Udder Infection Bacteria in Butter Made from Raw Cream.** C. S. BRYAN AND P. S. BRYAN, Mich. Agr. Expt. Sta., East Lansing, Mich. Jour. Milk Technol., *7*, No. 2: 65. March–April, 1944.

A study was made to determine the length of time pathogenic organisms of the bovine type would survive in butter.

The cream for churning was obtained from the milk of a cow, one quarter of whose udder was infected with *Str. agalactiae*, one with *Str. pyogenese*, one with a non-hemolytic *Staph. aureus* and the other with a hemolytic *Staph. aureus*, by the injection of 10 ml. of a 24-hour broth culture of the proper organism. Repeated examinations of the milk were made during the time the cream was being used for experimental purposes to be certain that udder infection had been accomplished.

The cream was allowed to separate by gravity and after removing was stored in an ice box at 40° F. Each day's supply was added for one week. The cream was then further contaminated by adding 200 ml. of a 48-hour broth culture of *Brucella abortus*, and the presence of all pathogens in the cream was confirmed. The cream was then divided into two lots; one lot was pasteurized at 145° F. for 30 minutes, and the other was not. It was found that pasteurization destroyed all of the pathogens in the cream.

The raw and the pasteurized creams were again each divided into three lots. One lot of each was churned immediately, while the other two portions of each were held for six days and twelve days at 70° F. before churning.

Half of the butter of each lot of cream was salted (2.0%), and half was not. The butter was kept in a refrigerator at about 45° F., and portions were examined twice weekly for the presence of the pathogens. The results showed that there was no difference between the salted and unsalted butters in any instance. No pathogens were found in the butter made from the pasteurized cream.

*Brucellus abortus* organisms survived for four months in the raw sweet cream butter, and for three months in each of the butters made from the raw cream ripened six and twelve days before churning.

The human and animal streptococci and the hemolytic and non-hemolytic staphylococci were recovered for six months from all of the lots of butter made from raw cream. L.H.B.

## CHEESE

**341. Bacteriology of Cheese. VII. Calcium and Phosphorus Contents of Various Cheeses, Including Relationship to Bacterial Action in the Manufacturing Procedures.** H. J. ZAHRNDT, C. B. LANE, AND B. W. HAMMER. Iowa State Col. Res. Bul. 325. March, 1944.

Analyses of 52 samples of Cheddar cheese made in Wisconsin, Iowa, and New York showed marked uniformity in calcium and phosphorus contents, the average being 1.14% Ca and 0.78% P on a dry basis. Analyses of 27 samples of Swiss cheese gave high contents of both Ca and P, but pasteurized milk Swiss cheese had less Ca and P than the raw milk Swiss cheese. The Ca/P ratio was very consistent for Cheddar and Swiss cheese.

The Ca and P contents of Edam cheese compared favorably with that of Swiss cheese. Blue cheese was noticeably low in minerals, for the Ca content averaged 0.51% and the P 0.54% in the dry matter. The Ca/P ratio was definitely lower. Cottage cheese contained 0.31% Ca and 0.72% P, while cream cheese averaged 0.1% Ca and 0.23% P. The Ca/P ratios were low.

The scores of the cheese were not related to Ca and P contents, a result that would be inevitable with no control of factors known to affect cheese quality. A.C.D.

## CHEMISTRY

**342. Some Antioxidant Properties of D-Iso Ascorbic Acid and Its Sodium Salt.** F. J. YOURGA, W. B. ESSELEN, JR., AND C. R. FELLERS, Mass. State Col., Amherst, Mass. Food Res., *9*, No. 3: 188. May–June, 1944.

The antiscorbutic activity of d-iso ascorbic acid was found to be one-twentieth of that of l-ascorbic acid (vitamin C); but the former oxidized more readily than the latter and, when in mixture, the d-iso form was prefer-

entially oxidized, leaving the l form unoxidized. It thus appears that d-iso ascorbic acid is an excellent antioxidant for l-ascorbic acid.

Sodium d-iso ascorbate had poor antioxidative powers toward l-ascorbic acid. F.J.D.

## CONCENTRATED AND DRY MILK; BY-PRODUCTS

**343. Protein-Aldehyde Plastics. Reaction of Formaldehyde with Deaminized Casein.** D. C. CARPENTER AND F. E. LOVELACE, New York State Expt. Sta., Geneva, N. Y. Indus. and Engin. Chem., Indus. Ed., *36*, No. 7: 680. July, 1944.

The combining ratios between formaldehyde and deaminized casein are established over a concentration range up to 6.85% formaldehyde. At any aldehyde concentration 45% as much aldehyde is bound by deaminized casein as by acid casein. The aldehyde bound by acid casein and deaminized casein agrees closely with that expected from the content of certain individual amino acids in the respective proteins. B.H.W.

**344. Metallic Substitutes for Hot-Dipped Tin Plate.** ROGER H. LUECK AND KENNETH W. BRIGHTON, American Can Co., Maywood, Ill. Indus. and Engin. Chem., Indus. Ed., *36*, No. 6: 532. June, 1944.

Tin conservation measures are described; and the methods of manufacture and characteristics of hot-dipped tin plate, electrolytic and Bonderized steel plate are discussed. Data on corrosion resistance of various types and combinations of coatings are given for cans packed with many fruits and vegetables and for evaporated milk. Evaporated milk was packed in cans made of electrolytic plate of 0.5 and 0.75 pounds of tin per base box which had been treated in various ways for corrosion resistance. The electrolytic plate cans packed with evaporated milk showed much less corrosion resistance than did the 1.25-pound hot-dipped plate cans which were used for control samples. B.H.W.

## DISEASE

**345. Contribution of *Streptococcus uberis* to the Plate Count of Milk.** H. W. SEELEY, JR., E. O. ANDERSON, AND W. N. PLASTRIDGE, Storrs Agr. Expt. Sta., Storrs, Conn. Jour. Bact., *47*, No. 5: 440–441. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

The complete milking of 23 *S. uberis* infected quarters was obtained with a sterile milking unit. When a selective blood agar medium containing crystal violet, mannitol, inulin and sorbitol was used, the *S. uberis* population of the samples was found to range from 30 to 44,000 colonies with a

logarithmic average of 3,000. There was no correlation between plate counts and leucocyte counts.

Of 15 strains of *S. uberis* incubated in milk for 60 hours, all multiplied rapidly at 60°, 70° and 97° F., and 10 cultures multiplied to some extent at 50° F. The population average of all cultures decreased at 40° F. Cultures held at 40° or 50° F. did not produce measurable changes in pH.

The authors believe that the *S. uberis* content of milk immediately after it is drawn usually has little influence on the plate count of high-count milk, but may contribute a large share of the flora of low-count milk, and that cooling to a temperature below 50° F. will prevent further changes in milk quality due to *S. uberis*. D.P.G.

**346. A Gastroenteritis Outbreak from Food.** R. C. PERRIELLO, Health Dept., Attleboro, Mass. Jour. Milk Technol., *7*, No. 2: 68. March–April, 1944.

Although evidence is not considered conclusive, it is quite probable that raw milk was the responsible food in this particular outbreak. L.H.B.

**347. Mastitis—Laboratory Tests and Their Interpretation.** J. M. FRAYER, Associate Dairy Bacteriologist, Vt. Agr. Expt. Sta., Burlington, Vt. Jour. Milk Technol., *7*, No. 2: 89. March–April, 1944.

A very good discussion of the following tests is given:

| | |
|---|---|
| Physical examination | Catalase test |
| Strip cut test | Chloride test |
| Brom Thymol-blue test | Microscopic examination |
| Modified Whiteside test | Hotis test |

Vermont's program is to eventually set up several demonstration herds with the idea to show what can be done with sound herd management, plus a certain amount of laboratory assistance, to lower the incidence of mastitis in the Vermont dairy herds.

The tentative diagnostic procedure will be as follows: In addition to the routine use of the strip cup, physical examination of udder and brom-thymol-blue test at the stable, aseptically drawn quarter samples (or pooled udder samples) will be taken for laboratory tests.

The Hotis test will be made on all samples, and those which are either positive or suspicious will be examined microscopically and plated on either Edward's blood agar medium or on plain blood agar as an additional check.

It is hoped that this procedure will detect incipient mastitis early and thus facilitate segregation and treatment. L.H.B.

**348. The Streptococcal Flora of the Non-Mastitis Udder.** J. J. REID, M. A. FARRELL, E. A. KEYES, AND J. F. SHIGLEY, Pa. State Col.,

State College, Pa. Jour. Bact., *47*, No. 5: 440. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

Monthly examination of 1,200 lactating cattle over a period of two years revealed that at some time during the period most of the animals shed streptococci in the milk. This was demonstrated by the Breed smear of incubated, sodium azide, brilliant-green treated milk. A few animals consistently showed neither streptococci by routine tests nor clinical evidence of udder trouble.

Twenty-five of the mastitis-free animals which had never been found to be shedding streptococci were selected for special study from two herds in which mastitis had not been a problem. Forty-ml. samples were taken from each animal and the samples were centrifuged immediately. The supernatant liquid was removed, and 5 ml. of veal infusion glucose broth containing brilliant green and sodium azide were added to the sediment. After incubation for 16 hours at 37° C., smears were examined for streptococci and blood agar streaks were made. Streptococci were demonstrated in each case. Beta hemolytic streptococci of Lancefield Group D were found in the milk of all these animals, and streptococci of other Lancefield groups were demonstrated in 22 of the 25 animals. D.P.G.

## FEEDS AND FEEDING

**349. Effect of Wilting on the Fermentation of Alfalfa Silage.** R. W. Stone, J. J. Reid, P. S. Williams, and S. I. Bechdel, Pa. State Col., State College, Pa. Jour. Bact., *47*, No. 5: 441. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

Seven silages, ranging in moisture content from 30 to 65 per cent, were put up with no treatment other than wilting before raking. Four silages were prepared from the same forage with ground corn and other preservatives. All fermented satisfactorily and produced a palatable product. The rate of fermentation and total bacterial count were proportional to moisture content. All wilted silages were relatively high in reducing sugar; those wilted to 50 per cent and below contained more, on a moisture-free basis, than those wilted to 65 per cent. Final pH was inversely proportional to moisture. Lactobacilli were predominant in all silages; in those containing 60 per cent or more moisture no other organisms were present in significant numbers. Below 60 per cent, yeasts were common and in two instances increased to numbers comparable to the lactobacilli. Some spore-forming rods were found in the drier silages. D.P.G.

**350. Stability of Carotene Added to Solid Carriers.** Emanuel Bickoff and Kenneth T. Williams, West. Region. Res. Lab., U. S. Dept. Agr., Albany, Calif. Indus. and Engin. Chem., Indus. Ed., *36*, No. 4: 320. April, 1944.

Oil solutions of carotene may be used to supplant the large quantities of

cod- and shark-liver oils formerly added to feeds as a vitamin A supplement. The effect of the carrier, the added oil (type and concentration), concentration of carotene and added antioxidants on the stability of carotene was studied. The addition of carotene in pellet form to certain dry carriers without protective measures results in very rapid loss. With protective measures, such as favorable storage conditions, the addition of certain oils and of very small amounts of antioxidants, and a reasonably low but significant concentration of carotene, the retention of carotene is greatly improved and suggests that pelleted mixtures containing extracted carotene may prove feasible as a supplementary feed. B.H.W.

## FOOD VALUE OF DAIRY PRODUCTS

**351. Vitamin A Content of Sheep's Colostrum and Milk.** G. HOWARD SATTERFIELD AND R. E. CLEGG, Univ. of N. C., Raleigh, N. C., AND ARTHUR D. HOLMES, Mass. Agr. Expt. Sta., Amherst, Mass. Food Res., *9*, No. 3: 206. May–June, 1944.

The average vitamin A content of the colostrum and milk of ewes, determined colorimetrically, was found to be 10.11, 6.88, 3.98, 3.37, 2.70, 1.03 and 1.10 Lovibond units per gram, respectively, for the first seven days of lactation. During the second and third weeks it was still lower. The vitamin A content of the colostrum and early milk was slightly higher for two-year-old ewes than for older animals. F.J.D.

**352. Iron Content of Market Milk.** FRANCES A. JOHNSTON, Dept. of Ped. and Dept. of Home Econ., Univ. of Chicago, Chicago, Ill. Food Res., *9*, No. 3: 212. May–June, 1944.

Sixty-one bottles of market milk from 25 companies, in 12 communities, were analyzed for iron by Stugart's thiocyanate method. The iron content ranged from 0.114 to 0.650 mg. per kg. The mean was 0.319 mg. per kg. Probably the best value to use for average market milk is 0.3 mg. per kg. This is one-seventh of the value used in current tables of food composition. F.J.D.

## ICE CREAM

**353. Effect of Various Temperatures of Storage upon Chemical and Physical Properties of Powdered Egg Yolk as Related to Its Use in Ice Cream.** P. H. TRACY, JOHN SHEURING, AND W. A. HOSKISON, Dept. Dairy Husb., Univ. of Ill., Urbana, Ill. Food Res., *9*, No. 2: 126. March–April, 1944.

At high temperatures of storage (room temperatures and above) powdered egg yolk was found to decrease in pH and to lose solubility progressively. At low temperatures (40° F. and under) little effect was noted.

Bacterial populations of the powder were found to decrease more rapidly as the time and temperature of storage were increased, and the color to increase directly with the temperature of storage. The flavor also seemed to deteriorate directly with the time and temperature of storage, and the presence of milk solids in the egg-yolk powder accelerated the rate of deterioration.

Best flavored ice cream resulted when egg-yolk powder stored at low temperature (40° F. or under) was used, but even powder stored at temperatures of 90° F. for as long as 18 months, when used in quantities representing 0.5 per cent of the mix, did not have a serious flavor effect.

Time and temperature of storage of egg-yolk powder could not be related to the whipping qualities or the melting characteristics of ice cream in which the product was used. F.J.D.

**354. Studies on the Bacteriology of Stored Dried Egg Powder.** STANLEY E. HARTSELL, Dept. of Biology, Purdue Univ., Lafayette, Ind. Jour. Bact., *47*, No. 5: 439. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

Neither packaging nor compression influences the bacterial content of dried eggs. Higher storage temperatures decrease the total bacterial count more rapidly than lower temperatures. Yeast-water agar is superior to Standard Methods agar for obtaining total bacterial counts and for the isolation of bacteria present in stored dried egg powder, irrespective of the temperature of incubation. Higher counts were obtained when plates were incubated at 32° C. than at 37.5° C. D.P.G.

**355. The Occurrence and Possible Significance of *Salmonella* Organisms in Canadian Dried Egg Powder.** N. E. GIBBONS AND R. L. MOORE, Div. of Appl. Biol., Natl. Res. Council, Ottawa, Canada. Jour. Bact., *47*, No. 5: 439–440. May, 1944. Abs. of paper presented at the 45th General Meeting, S. A. B.

The examination of 380 carlots of dried egg powder resulted in the isolation of 8 types of *Salmonella* from 28 lots. The numbers present were small, ranging from less than one per gram in 13 samples to 54 per gram in one sample. The distribution within carlots was spotty. Laboratory spray drying produced a 99.9 per cent reduction in the *Salmonella* count and a 65–80 per cent reduction in the total viable count. On storage the number decreases rapidly. *Salmonella* organisms could not be detected in cooked, reconstituted powder that had been inoculated with 8,000 to 2,000,000 organisms per gram. The authors conclude that, if reconstituted egg is properly kept and cooked, there should be little danger from powders containing as few *Salmonella* organisms as reported. D.P.G.

## MILK

**356. The Effects of Farm Cooling Methods and Transportation on the Temperature of Night's Milk.** S. ABRAHAM AND C. H. OUTWATER, City Dept. Health, New York, N. Y. Jour. Milk Technol., 7, No. 2: 78. March–April, 1944.

The temperature of the milk at the receiving platform does not necessarily give the inspector the actual temperature to which the night's milk was cooled on the farm.

A survey was made on 2233 farms in the New York City milk shed to determine (1) the actual temperature to which the night's milk was cooled prior to its being loaded on the trucks; (2) the types of cooling methods employed; (3) the relative efficiency of the various methods used; and (4) the effect of various transportation practices on the temperature of the milk at time it reaches the plants.

It was found that 53.6% of the producers had cooled their milk to below 51° F., 42.7% to between 51° and 60° F. and only 3.7% of the producers' milk exceeded 60° F., the maximum temperature permitted by the sanitary code. This was during the months of June, July, August and September.

The methods used on these farms were as follows: 45.6% had mechanical coolers; 19.3% cooled with spring water; 16.5% used ice; and 18.6% depended on pumped well water without the use of ice.

The average summer temperatures of the milk on these farms for the various types of cooling were as follows:

Mechanical coolers—42.7° F.
Ice water cooling—50.0° F.
Spring water cooling—53° F.
Pumped well water (no ice) cooling—56.5° F.

A total of 154 routes were studied; of this number only 18 vehicles carried ice for refrigerating the milk during transportation. These 18 vehicles used an average of 316.9 lbs. of ice each, travelled an average of 62.7 miles, and carried an average of 82.3 cans of milk. The average temperature of the milk at the farm was 52.7° F. and at the plant was 52.8° F. The temperature change from the farm to the plant ranged from a minus 4° to a plus 7° F. The vehicles not iced travelled an average of 26 miles and carried an average of 65.2 cans of milk. The average temperature of the milk at the farm was 47.8° F., and 52.2° F. at the plant. The temperature change from the farm to the plant ranged from a plus 1° F. to a plus 15° F.

Only one vehicle on which no ice was used was insulated, and only two vehicles on which ice was used were insulated. L.H.B.

**357. Applying the Direct Microscopic and Swab Tests in a Milk Control Program.** N. O. GUNDERSON, Commr. Health, AND C. W. ANDER-

SON, Lab. Dir., Rockford, Ill. Jour. Milk Technol., *7*, No. 2: 73. March–April, 1944.

The authors conclude that the standard agar plate count has outgrown its usefulness as a milk control procedure for pasteurized milk as well as raw milk.

The direct microscopic test on both raw and pasteurized milk and the swab test for determining cleanliness of equipment offer definite advantages over the methylene-blue reduction test and the coliform test. L.H.B.

**358. Scientific Advances in the Dairy Industry (A Review of Much Current Literature).** J. H. SHRADER, Wollaston, Mass. Jour. Milk Technol., *7*, No. 2: 98. March–April, 1944.

A fine review of 110 recent articles pertaining to new developments in the dairy industry. L.H.B.

**359. Relieving Labor Problems in Creameries.** C. R. ROBERTS, Sheffield Farms Co., New York, N. Y. Jour. Milk Technol., *7*, No. 2: 85. March–April, 1944.

Our labor problems can be reduced by (1) using automatic machinery wherever possible, (2) job training, (3) incentive plans, (4) giving more attention to our present personnel, and (5) encouraging employee cooperation by using "suggestions" made by them. L.H.B.

# *Who'll make it* TWO BILLION?

Of course the answer is: only the public can make the two-billion-gallon ice cream year a reality. It has the power to do it—the appetite and the money. But the public doesn't just give volume sales in the billions without receiving exceptional value in return.

So the way to make post-war plans practical is to give plenty of thought to what the public wants.

Very likely the people will want half-gallon containers for the low-temperature refrigerators now on the drawing board. Undoubtedly consumers will expect quality to equal, then surpass, pre-war ice cream. Advances in distribution methods also will be expected. *But above all*, the public will demand the finest flavor quality obtainable. And one look at the public's preference for flavors will convince even the most inexperienced post-war planner where to begin.

With vanilla accounting for more than 50% of all the ice cream sold, it should receive at least half of all the study and planning and promotion.

Just think of it: out of one hundred and forty-eight flavors reported in the pre-war year of 1938, vanilla produced more sales than the other one hundred and forty-seven flavors put together.

No wonder David Michael & Co. takes its work, in the constant improvement of vanilla flavoring, so seriously. Research and development in this field can affect 50% of all ice cream sales.

*U. S. consumption of ice cream for the year 1938*

BY FLAVORS

| | |
|---|---|
| VANILLA | 51.26% |
| CHOCOLATE | 16.36% |
| STRAWBERRY | 7.95% |
| BUTTER PECAN | 3.67% |
| PEACH | 1.46% |
| MAPLE | 1.07% |
| CHERRY | 1.01% |
| PINEAPPLE | 0.91% |
| COFFEE | 0.62% |
| BURNT ALMOND | 0.17% |
| 138 other flavors | 15.52% |

*Source: International Association of Ice Cream Manufacturers*

Mixevan, with its ability to give vanilla ice cream the delicious mellow mildness so much desired by the public, is ready to help gain the two-billion-gallon mark.

At the top of your post-war planning sheet just make this note: to hit the two-billion mark, vanilla ice cream will have to be so good that the public will buy more than a billion gallons of this one flavor a year. . . . Then, when you are ready to put plans into work, let us hear from you.

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*The American Dairy Science Association* was organized to advance the general welfare of the dairy industry, especially by the improvement of dairy instruction by the stimulation of scientific research in all phases of the subject and by improvement in methods of conducting extension work.

*Membership.* Any person is eligible to membership who is formally announced by an Agricultural College or Experiment Station, or by the Bureau of Dairy Industry of the United States Department of Agriculture or by the Canadian Department of Agriculture as an instructor, extension worker, investigator, or administrative officer connected with the dairy industry, or any person filling a position of responsibility connected with the dairy industry who has had a college or university training in technical science, or any person filling a responsible position in the dairy industry of a professional character requiring a technical knowledge of dairying of a high order. The membership fee is $5.00.

The dues are $5.00 a year, $3.00 of which is for a year's subscription to the *Journal of Dairy Science*. Correspondence regarding membership and dues should be addressed to R. B. Stoltz, Ohio State University, Columbus, Ohio.

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of definitely better flavor & aroma-producing qualities.

The standard with foremost operators, agricultural schools & colleges.

**FLAV-O-LAC FLAKES** (shown) produce a quart of the finest starter on a single propagation. Single bottles $2.00.

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**produce 40 quarts of starter on a single propagation. Single bottles $3.00**

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## How To Quickly Brighten Dull-Looking Milk Cans!

If you want to spruce up dull and dingy milk or cream cans . . . remove rust film from can exteriors . . . hard water deposits and milkstone from interiors . . . use that successful, can conditioning material . . .

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Combining light rust-removing properties and emulsifying action in one material, it brightens and cleans both exterior and interior surfaces of cans. Designed for use in can washing machines, it also helps keep machine, spray jets and piping free of limescale. Ask us to send you complete details.

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## Just charge the can washer with

# CANRITE

Dairy plants that sacrifice time once or twice a year for the dreaded task of hand-scrubbing milk cans will be glad to hear about CANRITE . . . a remarkable discovery recently announced by the Diversey Research Laboratories.

Now . . . with CANRITE in the can washer, stubborn milkstone can be removed by machine . . . ten times faster than by the slow laborious task of hand scrubbing!

Diversey CANRITE removes milkstone and hard water scale from tinned-iron milk cans safely. Because of the short time of contact in the can washer (not over 15 seconds), CANRITE possesses unusually powerful milkstone and scale dissolving characteristics . . . powerful wetting action to assure immediate contact with the oily, greasy milkstone contamination.

P. S. Once milkstone has been removed from the cans with CANRITE, they can be kept clean and sweet-smelling by using Diversey NOVEX in the can washer. **THE DIVERSEY CORPORATION, 53 W. Jackson Blvd., Chicago 4, Ill.**

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Winning touchdowns come from tightly-knit team play—eleven men all working toward one goal.

Increasing public demand for foods "rich in dextrose" is another great example of team play.

Producers, processors and distributors have all pitched in to make dextrose known as "the one sugar the body uses directly for energy." They have created the ever growing market for foods which contain dextrose. Consumers are learning that *dextrose on the label, means food energy in the product.*

**Tune in**
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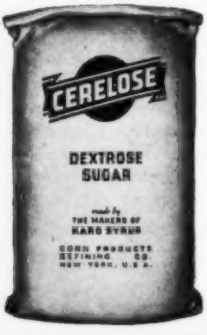


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Cheese Rennet and Color
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FOR ALL DAIRY SANITATION

B·K CHLORINE BACTERICIDE

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ACCEPTED BY PUBLIC HEALTH AUTHORITIES

Every year, because of poor quality, enough milk and milk products to meet the annual nutritional needs of 120,000 soldiers are wasted. This statement, issued by a University of Illinois College of Agriculture authority, calls for action.

For *fast* action, the answer is B-K Chlorine Bactericide . . . in up-to-the-minute dairies and creameries. Its available chlorine goes right to work as a sanitizer. Efficient and rapid, it costs little to use. Use B-K daily as a sanitizing rinse, and a helpful shortcut to increased butter production . . . through decreased rejections.

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Students can readily use The Performance Register of The American Guernsey Cattle Club for

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**Enlisting the skills for wartime production is only the beginning. Keeping the production soldiers healthy is an absolute requisite to victory.**

**Public health laboratories are aiding in this fight and the microscope is playing a vital part in the identification of micro-organisms which cause disease.**

**Today, this crusade is resulting in fewer hours lost by illness—in better public health.**

**Spencer Microscopes, Microtomes and related instruments are serving this cause in laboratories throughout the world.**

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For best results in the cheese vat, specify Marschall's. High in strength, pure and uniform.

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## New Slant on CALF SCOURS

Extensive research at the Wisconsin Agricultural Experiment Station shows that most cases of calf scours are due to a dietary deficiency. The contributing factors are vitamin A and niacin. The same formula used in the Wisconsin studies for preventing and curing nutritional scours has been employed in ANADEX Kaf-Kaps.

Daily use of ANADEX for the first few weeks is helping dairymen save calves from scours and attendant disorders. Calves on skimmilk diets receive in ANADEX adequate vitamin A till they are eating freely of hay and grain. The niacin requirements are supplied till the calf begins to synthesize this nutrient. In addition adequate vitamin D is provided for rapid growth and strong skeletal development.

ANADEX Kaf-Kaps are 10 minim (⅝ cc) capsules. Easy to administer . . . no loss in feeding or in potency. It requires about 25 Kaps per calf, at a cost to the dairyman of 7¾¢ to $1.00 depending on size of package. Inquiries invited.

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Our bulletin 30c is fully descriptive—Write for it.

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DIET AND HEALTH

★ The National Dairy Council is the educational and sales promotional organization of the dairy industry. The Council operates nationally through its central office in Chicago and locally through its more than thirty unit Councils in all parts of the United States.

The National Dairy Council program reaches every member of the family through the chief opinion-forming groups in all professional and educational fields. Such key groups as physicians, dentists, teachers, nurses, nutritionists, writers and public health workers are kept informed constantly of the dietary importance of all dairy products.

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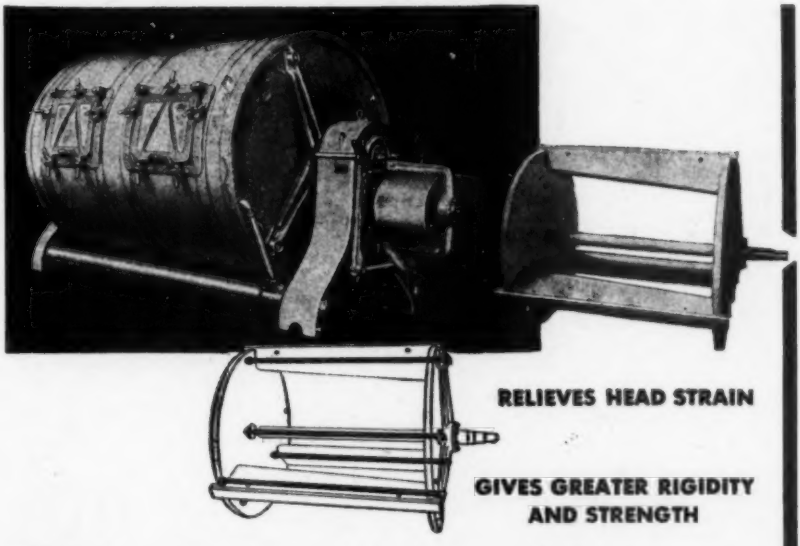

**RELIEVES HEAD STRAIN**

**GIVES GREATER RIGIDITY AND STRENGTH**

WHEN you choose a CP Sanitary No-Roll Churn with its exclusive sealed-in tie-rod features, you get the strongest and most sanitary construction possible. Note from illustration above how the tie-rods—entirely sealed away from churn interior—extend through the shelves and are fastened outside of the gudgeon arms. Center working bar also has the sealed-in tie-rod feature.

*Unexcelled performance* — the tapered shelves and center working bar work the product the full length of drum and provide uniform composition.

Buttermakers like the fact that with the CP No-Roll Churn they can work the butter hard or soft without its getting sticky . . . obtaining a dry, firm waxy textured butter which GIVES MAXIMUM YIELD WHEN PRINTED. Ask for Bulletin K-689.

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4TH WAR LOAN

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# *Detection of*
# Coliform Bacteria

**BACTO–BRILLIANT GREEN BILE 2%**

is recommended for the detection of coliform bacteria. This medium conforms in every way to the brilliant green lactose peptone bile described in the current editions of "Standard Methods for the Examination of Dairy Products" and "Standard Methods of Water Analysis" of the American Public Health Association. Results obtained by the direct inoculation of water, milk and dairy products or other food materials into fermentation tubes of this medium are reliable and accurate.

**BACTO–FORMATE RICINOLEATE BROTH**

is also employed for the detection of coliform bacteria. The medium is used in fermentation tubes which are inoculated directly with the sample or dilution. Bacto-Formate Ricinoleate Broth conforms to the "Standard Methods" formulae.

**BACTO–VIOLET RED BILE AGAR**

is recommended in "Standard Methods for the Examination of Dairy Products" for the direct plate count of the coliform bacteria. This medium is especially prepared for direct enumeration of coliform bacteria in water, milk and other dairy or food products. Upon plates of medium prepared from this product subsurface colonies of the coliform types are generally surrounded by a reddish zone of precipitated bile. Due to the inhibitory action of the medium toward other types accurate counts are obtained after incubation for only 18 hours.

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THE TRADE NAME OF THE PIONEERS
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